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FINANCING PUBLIC UTILITIES

By H. A. Van Norman

(Chief Engineer and General Manager, Bureau of Water Works and Supply, Department of Water and Power, Los Angeles, Calif.)

Los Angeles' Department of Water and Power is one of the outstanding examples of successfully operated publicly-owned utilities in the world.

This branch of the City government operates the second largest water system in the world and the largest municipally-owned electric system.

The Department of Water and Power is a self-sustaining, revenue producing utility. It supplies water and electricity to its more than 400,000 regular customers in a city of 1,300,000 population in an area of 441 square miles.

The physical properties of this Department extend from the Harbor to the snow capped High Sierras, a distance of nearly 300 miles to the north of Los Angeles.

Assets of this Department are in excess of $200,000,000. The annual gross income is more than $25,000,000 derived from sales of water and electricity.

Authority for the establishment and operation of the Department of Water and Power with its Bureau of Water Works and Supply and its Bureau of Power and Light is contained in the City Charter which vests a Board of Water and Power Commissioners with power to administer the affairs of the Department.

Subject to certain limitations contained in the City Charter, the Department of Water and Power is an institution independent of other branches of the City Government.

Privately-owned utility financing and operation in California must pass in review before the State Railroad Commission which must approve and regulate the actions of those utilities. The publicly-owned utilities are administered without requiring supervision of the State Commission.

Finances of the Los Angeles Department of Water and Power are authorized by the City Charter and may be provided either through revenues or bond funds or both. In an emergency short term notes may be drawn. This emergency, thus far, has not arisen.

Good management of a public utility demands that the products of the utility be sold and distributed at or near cost. This must be done with due regard to the necessity for providing substantial surplus funds to meet bond interest and redemption charges.

In Los Angeles the City Charter provides that all principal and interest charges on general water and power bonds *must* be paid from revenues of the two bureaus.

Early in the history of this Department tax funds were set apart for the benefit of the Department until it had completed its works and reached a paying basis. These sums from tax funds gradually are being paid back by the Department.

While endeavoring to sell our products to the consuming public at cost we do not lose sight of the following vitally necessary provisions:

1. To operate and maintain all facilities of the Department in proper condition commensurate with good service.
2. To conserve the physical properties as good security for borrowed money which makes its construction possible.
3. To pay interest on all outstanding debts.
4. To provide for all replacements within the life of the debt obligation.
5. To create additional assets which will preserve a safe investment margin between debt and security, in order that future investments may be attractive to capital.
6. To provide reserves for all reasonable contingencies, catastrophes or economic changes, in order to stabilize product prices to consumers and in case of Los Angeles caring for bond maturity payments. Our bond maturities usually extend over a period of 40 years.

It seems to me the financing of municipal corporations as provided and authorized by our City Charter is the most equitable for the people. Municipal organizations, as a rule, and as particularly ap-

plied to the Department of Water and Power, are self-supporting as I indicated at the outset of this paper.

We are in the business of serving the people with essentials of life: water, light and power. In Los Angeles we have no competitor in the field of water service. In the management of this non-competitive commodity we have maintained the remarkably low rate of 13 cents for 100 cubic feet.

To operate a municipal enterprise successfully and to meet its obligations, as previously indicated, all major additions and betterments to the system should be financed from bonds. By doing this the debt obligations are spread equitably over future generations.

A serious burden would be placed upon the shoulders of the water rate payer if charges for additions and betterments to plant and system were paid out of revenues. Most of the rate payers are wage-earners. Study, for example, this year's Department budget estimated at $10,390,000, for betterments to plant and system. Of this amount $8,430,000 will be provided by bond funds. We have at present 323,000 active services. If water revenues paid for these improvements, the sum required from each active service would be about $55 a year, reflected in an increased water rate of approximately 230 per cent.

On the other hand, when these major improvements are financed from bond funds, this burden is materially reduced and is spread over a long period of time. In my opinion, this is a vastly more equitable distribution. Applying this thought to the above mentioned example, the revenue from each active service, in accordance with our present ordinance rates, would average $30 a year. Of this amount $13 would be used to care for interest and redemption requirements on all outstanding bonds.

I heartily concur in the "ready-to-serve" charge advocated by most authorities on municipal water works. This charge would increase revenues. Necessarily, many miles of pipe are laid facing vacant property. Installation of these utilities increases property values, but no water revenues are derived from the property. There is compensation for this when bonds are an obligation of the City, but if they are an obligation of a municipal utility the burden is placed upon the consumer. If a water tax of, say, 25 or 50 cents a month could be applied to the vacant property, two benefits would result: one, increased revenues, and the other, stabilization of water rates.

Another water revenue source given too little thought is the fire

prevention charge to the City. For all large cities the rate for this purpose should be approximately 12 percent of the gross earnings. If this additional earning could be added to the revenues of the Department of Water and Power it would increase them approximately $1,250,000 annually.

Experience has shown that the costs of the portion of water works involved by fire protective service generally constitutes from 10 to 20 percent of the entire cost of the physical properties of the water works. You will find that in cities that have adequate fire protection and a high rating with the National Board of Fire Underwriters, the insurance premium for protection is reduced very materially. As a result, the consumer gains more on the reduced premium for fire insurance than he would pay in taxes for this necessary fire protection.

Other sources of income from which additions and betterments to the system can be made include acreage supply assessments, municipal improvement bonds, and donations in the aid of construction. These I shall explain briefly as follows:

ACREAGE SUPPLY ASSESSMENT

In making extensions in outlying territory, consideration and careful thought should be given to future growth and provision made accordingly. This territory may lie without as well as within the City limits and may not have contributed in any way toward defraying the bonded debt. The extra expense in designing the system to care for the needs of this territory properly is chargeable against the territory and, therefore, is allocated on the acre basis. When the consumer desires an extension of the water main, he must pay this acreage supply assessment before his application can be accepted for a service connection, this assessment being based on the area of the property to be served.

MUNICIPAL IMPROVEMENT BONDS

Whenever territory similar to that mentioned under "acreage supply assessment" desires water, these improvements can be made in two ways: first, by payment of an acreage supply assessment plus $1.60 per lineal foot for the extension, plus the service installation charge, depending upon the size of the service; or, second, areas lying within the corporate limits of the City of Los Angeles desiring to obtain a water supply from the municipal water system may, by petition, make a formal request to the Board of Water and Power

Commissioners for the formation of a Municipal Improvement District, the cost of said improvement to be paid for by a bonded District. These bonds are an obligation of this specific District, not a general debt against the Department.

DONATIONS IN THE AID OF CONSTRUCTION

If a subdivider or prospective consumer desires an extension from which there is likely to be no revenue for some time, he may have the extensions by donating the cost of construction, i.e.: for the installation of water mains at $1.60 per foot, fire hydrants at $100.00 each, and the service connection charges according to sizes desired. In cases of abutting property not belonging to the subdivider, a deposit of 80 cents per front foot is required, such deposit to be refunded to payor or his assigns in semiannual installments as the frontage tax is collected. This return is based upon the lot frontage at 80 cents per front foot.

CONCLUSION

In conclusion, additions and betterments to plant and equipment, which are assets of the Department, are properly financed from at least four sources of money: bonds, surpluses (unappropriated), reserves, and donations in the aid of construction. This is somewhat different from privately-owned public utilities where the same financing is made in the order of bonds, stocks (preferred and common), reserves, surpluses (unappropriated), and donations in the aid of construction.

Southern California, and particularly Los Angeles, has grown so rapidly in the past few years, the financing of the Department of Water and Power by means other than by bonds would have placed a burden upon the then existing population that would have been staggering.

Public response to calls for approval of needed water bonds has been remarkably fine. The faith the people have in a municipally owned plant was first expressed in 1901 when the people by a majority of 5 to 1 voted $2,000,000 bonds issued for the purpose of acquiring the old Los Angeles Water Company, embracing the water works standing in the name of the Crystal Spring Water Company, East Side Spring Water Company, and the Los Angeles Water Company, including all properties real and personal; and the properties acquired

at that time formed the nucleus of our present Department of Water and Power.

In 1905 and 1907 the people again showed their faith in their municipally owned enterprise when they voted $24,500,000 to finance the construction of the Los Angeles Aqueduct by a majority of over 10 to 1. During the subsequent years up to and including 1925, there was voted a total of $34,610,000 with an average majority of 5 to 1—for the purpose of financing additions and betterments to plant and system. In 1930 the people were asked to approve the financing of a $38,800,000 construction program for the purpose of protecting our water rights and acquiring additional water bearing lands in the Owens Valley and Mono Basin and to make needed additions and betterments to plant and system; and they responded with a majority vote of 8 to 1.

Thus have the people of Los Angeles stood loyally by their water system when it needed funds to carry on its activities.

(*Presented before the California Section meeting, October 28, 1932.*)

SOLVING A SUCTION-LIFT PROBLEM IN AN AUTOMATIC PUMPING STATION

By Edward I. McCaffery

(*Mechanical Engineer, With Sanborn and Bogert Consulting Engineers, New York, N. Y.*)

Water District No. 1 of the Town of New Castle, Westchester County, N. Y. has completed works whereby it will be supplied with water by the City of New York from the Catskill Aqueduct. The normal flow line of the cut-and-cover aqueduct at the point of intake is at approximately El. 365, the invert at El. 349 and the center line of the two centrifugal pumps in the pumping station, which is located approximately 150 feet away from the aqueduct, is at El. 374. Topographical considerations placed the pumping station at a distance from the aqueduct, requiring a long suction. The normal static suction lift is about 9 feet, depending on the depth of flow in the aqueduct. Approximately 15,000 feet from the pumping station is located a standpipe of 2,000,000 gallons capacity; it is but 25 feet high, and the water level when full is about El. 700.

The chief features of installation and operation which required study and experimentation were:

1. A long suction line involving automatic priming;
2. A screening device on the suction line;
3. Chlorinating and lime-feed machines on the suction line, to start and stop in unison with the pumps;
4. Automatic operation of two electrically-driven centrifugal pumps, according to the water demands, except that during certain daily periods in winter when the use of power is forbidden by the contract.

SUCTION LINE

The simplest construction for a suction line would be a concrete chamber adjoining the aqueduct with a hole broached through the side; a 16-inch cast-iron pipe connecting the chamber to a wet well beneath the pumping station; and short suction lines with foot valves in the wet well. Such a system would have facilitated the priming

of the pumps for automatic operation, but failed to meet the approval of the Department of Water Supply of the City of New York which safeguards the Catskill aqueduct by allowing connections through the arch only.

To meet this requirement, a suction line about 150 feet long was laid, a hole was cut in the arch of the aqueduct in which a 12-inch cast-iron pipe was placed in a nearly vertical position, the lower end resting on a shoe on the invert and securely held in place by the wedging action of the shoe. The pipe extends through the hole in the arch which was refilled with concrete outside the pipe, so that the foot of the pipe is not readily accessible.

A foot valve for priming could not be used as it would not be accessible for maintenance; its function is replaced by an automatic vacuum system, which keeps the pumps continually primed, and which operates independently of the pumping units. To cut down entrance losses, slots 4 inches wide and 12 inches high, 120 degrees apart were cut in the 12-inch pipe in three rows 18 inches on center vertically, starting about 24 inches above the invert of the aqueduct.

STRAINER

Above the aqueduct arch a 12-inch cast-iron quarter-bend and increaser joins a 16-inch cast-iron pipe, about 70 feet long extending to a screen chamber housing a Blackburn-Smith self-cleaning strainer, which is in reality a part of the suction system. The strainer is of special design and consists of a large cast-iron shell housing a single bronze paraboloid-shaped perforated basket capable of passing 2250 g.p.m. At the bottom of the strainer is an 8-inch outlet for cleaning, controlled by a quick-opening valve. Cleaning is accomplished by high-pressure water directed against the inside of the basket from nine 1¼-inch spray nozzles, equally spaced circumferentially at the outlet end of the strainer and supplied with high-pressure water from the distribution system through a quick-opening valve. On either end of the strainer are 16-inch gate valves which are closed before starting to clean. After cleaning, which takes about 20 minutes, the strainer is filled with water from the nozzles before the 16-inch valves are opened, thus retaining the suction.

CHLORINE AND LIME-FEED EQUIPMENT

On the suction side of the pumps, the water is chlorinated and treated with lime by machines supplied by the Wallace and Tiernan

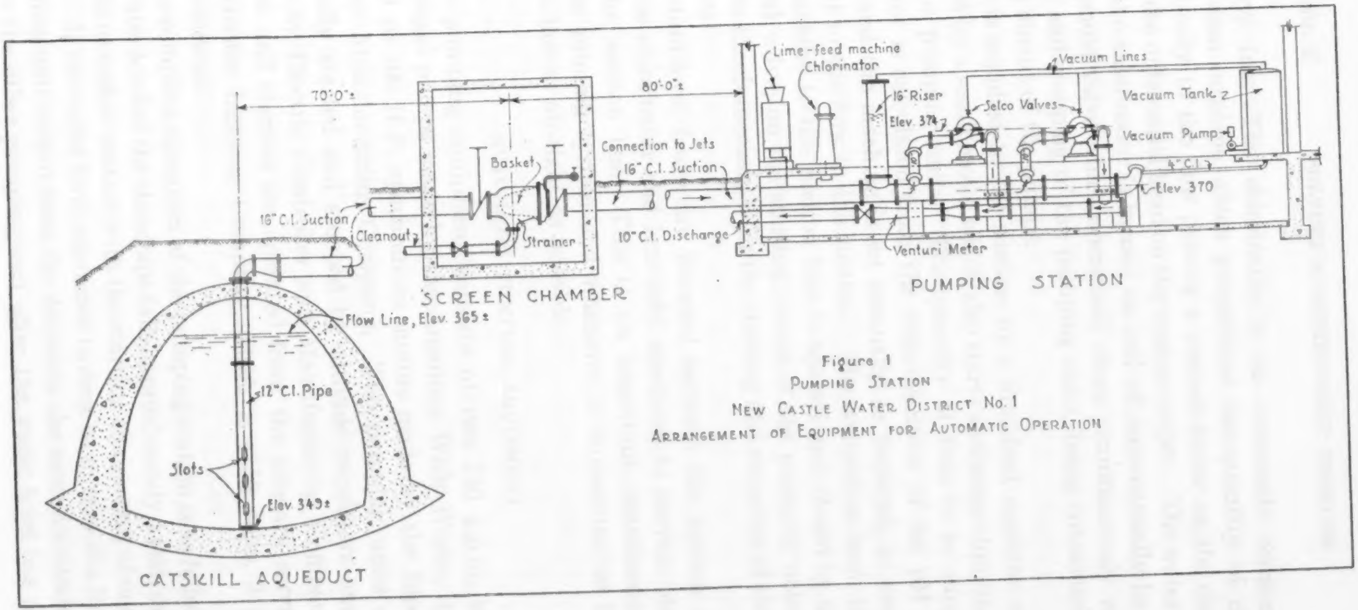


Figure 1
Pumping Station
New Castle Water District No. 1
Arrangement of Equipment for Automatic Operation

additional foot, to 5 feet below the full level. Both pumps continue to operate until the standpipe is full, when they are automatically stopped by the altitude regulators.

On the switchboard, a manual transfer switch is provided so that the sequence of operation of the two pumping units may be reversed.

The contract with the power company prohibits the operation of the pumps between 4.30 p.m. and 9.30 p.m. during the winter months. This requirement is fulfilled by a Sauter self-winding electric time-switch, which prevents the automatic operation of the station during the prescribed period.

VACUUM SYSTEM FOR CONTINUAL PRIMING

The priming system consists of a closed steel vacuum tank 30 inches in diameter and 6 feet high, installed on the floor of the pumping station. The bottom of the tank is connected to the blanked end of the 16-inch cast-iron suction header by a 4-inch cast-iron pipe, so that water passes both pump suctions, before entering the tank. The reason for locating the tank beyond rather than ahead of the pumps was to provide a vacuum where, when both pumps are operating, it would offset any tendency of the first pump to pull water away from the second.

For exhausting the air from the pump casings and the vacuum tank, and for maintaining the water level in the tank above the tops of the pump casings, two motor-operated Beach-Russ vacuum pumps are connected by a 1-inch pipe to the top of the tank. The motors of these pumps are automatically started and stopped according to the water level in the tank, by means of two Fisher liquid-level controllers installed on the outside of the tank, one 8 inches higher than the other. The additional level controller safeguards the priming of the pumps by starting the second vacuum pump whenever the level in the tank drops 8 inches, by reason of the first vacuum pump failing to function.

A one-inch pipe extends from the top of the vacuum tank over the tops of the pump casings, $\frac{3}{4}$-inch pipes from it connecting to the top of each pump to exhaust the air in the pump casing. An air valve on each $\frac{3}{4}$-inch line passes air but excludes water, by opening when the pumps are idle, and closing with the water pressure when the pumps start. Originally a $\frac{3}{8}$-inch valve of the float variety was used, but proved inadequate to remove the large quantity of air. A valve of the Selco type with larger air passages corrected this difficulty; it is

a special design of the Jenkins Valve Company whereby a spring placed under the seat of the valve keeps it open under a vacuum of about 20 inches.

OPERATING DIFFICULTIES

When the pumping station was tested, pump No. 1, nearest the aqueduct, failed to retain its prime or pump any water when pump No. 2 was operating, unless the gate valve on the discharge line of pump No. 2 was throttled nearly down and slowly opened by hand after pump No. 1 started to operate; even this method proved undependable as pump No. 1 frequently lost its prime when both pumps were running. The suction lift during the pump tests was approximately 9 feet.

Inspection revealed a large amount of air entering the suction line whenever the pumps started. Pump No. 1 being nearest the aqueduct acted as an air trap and received the greater quantity of air. Every possible point where air might enter the suction line was inspected and made tight; the entire suction line outside the aqueduct was recalked; but the trouble persisted. Possibly air entered through an opening in the suction line inside the aqueduct which was inaccessible for calking, or air is entrained in the Catskill water.

Pump No. 2 which was used to supply water for the District in the meantime, operated automatically, but not satisfactorily under the lesser quantity of air coming to it; the air entrained in the water delivered to consumers gave an unattractive milky appearance, causing many protests. The rumbling of pump No. 2 when operating would indicate that it was handling an abnormal quantity of entrained air.

To improve this unfortunate situation, it was evident that more air must be removed. A 16-inch cast-iron tee was inserted in the suction line next to the tee leading to pump No. 1, and a 16-inch cast-iron flanged riser pipe about 7 feet long with a bolted blank-flanged top was erected on this tee. This provides an additional vacuum tank. A 1-inch vacuum line was run from the top of the riser to the top of the vacuum tank. As an additional safeguard to keep air out of the pumps, a metal plate gasket was inserted in the flanges between the new tee and the tee connecting to pump No. 1; this gasket extends down into the waterway 4 inches to trap any air coming towards the pumps and divert it into the 16-inch cast-iron riser, from which it is exhausted.

The addition of the new riser and metal gasket evidently corrected the difficulty for since their installation both pumps have been operating automatically without any priming troubles and, in addition, the appearance of the water delivered to consumers has been improved.

ACKNOWLEDGMENTS

Charles H. Sells, Inc. Pleasantville, N. Y. are Civil Engineers to District No. 1, with James Hannan, Jr. in immediate charge. Sanborn and Bogert, New York City, acted as Consulting Engineers on the equipment of the pumping station, with the writer in direct charge. Wm. J. Creighton, New York City, was the Architect. The Suburban Engineering Company, 15 West 38th Street, New York City were sub-contractors on the equipment of the pumping station; the general contractor, Antonio Lambo, Waterbury, Connecticut, installed the suction line and strainer.

LOCATION RECORD FOR DISTRIBUTION SYSTEM

By A. H. Miller

(Water Works Superintendent, Sheboygan, Wis.)

The water supply system for Sheboygan, Wis., was originated about 1888, by the American Water Works and Guarantee Co. A small pumping station was built on the shore of Lake Michigan. An 18-inch intake 1200 feet in length drew the supply from the lake, and distribution was through steel and cast iron mains, varying in size from 2-inch up. The construction and location records of the above Company appear to be inadequate and available in part only.

In 1909 the City purchased the utility and has since operated the property as a separate city department under a commission of three members.

The City extends along the lake shore a distance of about 3½ miles and inland from the lake about 1½ miles. The corporate area is fairly rectangular, and is laid out in streets running north and south and avenues east and west. There are few diagonal streets, and the only irregularity in the layout is that due to S-shaped course of the Sheboygan River, running through the city from west to east at its middle. The topography of the city is almost flat with the average elevation about 50 feet above normal lake level.

The mains are of cast iron and range in size from 4- to 20-inch. A grid system with feeder lines interconnected with 4-, 6- and 8-inch lines in all the streets at the street intersections generally would be fairly descriptive of the layout.

There are four submerged river crossings all 12-inch.

The total mileage of mains is 125, and on about 5 miles of streets there are two mains. Mains are normally laid 6 or 8 feet from either curb. Hydrants number 1000 and there are about 1050 valves of various sizes installed. About 80 per cent of all streets are paved with concrete or brick. Valve box covers are set flush with the surface of the street and remain visible during the open season. During the winter season they are generally not visible. On macadam or tarred pavements valve box covers usually become covered in time,

so that they are generally concealed. The same is true, of course, of dirt street or roads.

The record system formerly used was concentrated at the main office at the City Hall. This included a large wall map of the entire city on a 300 feet scale showing the mains in the various streets. On this map main sizes were shown by various types of lines and valves in their approximate location. Hydrants were shown on the map and their connection to the mains indicated. Each street intersection was shown in detail on a card, which carried measurements from fixed objects available to the valve box covers. Usually each cover was located by tying in to two fixed points, such as, hydrants, building corners, catch basins, poles, etc.

In the plan just described no record was carried in the maintenance trucks. If reference must be made to records carried in the central office only, costly delays in making a shut off are bound to occur from time to time.

This plan had the following diadvantages:

(1) Records not readily available in the field.

(2) Dual system of records tends to confusion and does not give a clear picture of the particular shut off problem at hand.

(3) Intersection records frequently become too complicated with dimensions, lines, etc.

(4) More than two reference points are frequently needed on an intersection.

After the decision to make a radical change in the location record, a study of peculiarities of our system was made and the following facts developed.

(1) Seventy-five percent of the valves are entirely within the street intersection. Most of the remainder are reasonably near the intersection.

(2) The maximum distance from a chosen fixed point to any valve on or near the intersection was found to be 100 feet or less in almost every case.

(3) The possible reference points on or near the intersection were rated as follows in the order of availability. (a) Curb sewer inlets or catch basins (b) hydrants (c) sewer manholes (d) power or light poles (e) street marker signs (f) monuments or corner stones.

(4) The character of the concealment was found to be such that it is unnecessary to locate the valve nearer than within 1 or $1\frac{1}{2}$ feet. This is obvious from the fact that the concealing medium must be

removed by digging, shoveling, etc., which operations usually involve an area of several square feet.

The basic idea on which the present plan is constructed is to locate the valves within or near any intersection by measured distance from a hub or set up station together with the angular departure from an established line of sight from this hub to some other fixed object on the intersection.

At a typical street crossing on or near which are 4 valves, a catch basin curb is used as the hub and the line of sight established from it to the catch basin curb on the diagonally opposite corner. There is no confusion due to dimension lines, and yet each valve is completely and definitely located.

Because of the absence of this confusing detai lit is possible to incorporate this scheme in a map of a section of the city made on a reduced scale so as to give a picture of whole distribution system adjacent to a given point.

A sectional map is used covering about 30 square blocks of city area. Assuming now that at any given point within this area the occasion for a prompt shut off should arise, all the information necessary to make such a shut off is readily available from this single print. Sizes of mains are shown so that the valve can be operated intelligently. Hydrants are shown only when more than one main is present in the street, because frequently it is desirable to test for tightness of a shut off through such hydrant.

The city is divided into 42 sections, each section completely shown on one print.

Since the distance to valves from the hub is with few exceptions less than 100 feet, and since there is an allowable variation of at least 1 foot in location of a valve, it is not necessary to get the angle of departure nearer than one degree. Accordingly it was decided to develop a simple protractor to measure the angle of departure.

The instrument in use consists primarily of a tripod with one vertical leg constructed of standard steel pipe. A tapered spindle is machined to receive the graduated circular platten of 12-inch diameter. Attached to the platten is a member carrying a sighting point at a distance of 16 inches from the center spindle point. Mounted on a threaded hub of the platten is a rotating member carrying the movable sighting point. The rotating member is held in control by a tension spring under a collar threaded to the hub of the platten.

One end of the rotating member is pointed to indicate on the graduated circle the number of degrees of departure.

The platten itself may be locked by means of a knurled collar threaded to the main spindle.

The operation is briefly as follows: The tripod is set up on the hub with the center leg substantially vertical. The graduated platten is then placed on the spindle and rotated to focus the fixed sighting point on the second fixed reference point, this establishing the base line from which departures are measured. An arrow on the record map shows the direction of sight.

The platten is then locked to the spindle and the rotatable member offset the number of degrees indicated. This determines the line along which the linear measurement is to be made. The end of the tape is then hooked on a ring hook on the vertical leg of the tripod and run out the indicated distance along the line established and the location of the valve thus completed.

The mapping plan here outlined has been in use only a short time, but its usefulness and adaptability have been demonstrated without question. Its simplicity in principle and application is such that anyone wholly unfamiliar with our distribution system could make a prompt shut off at any point if he possessed only average intelligence and training, even though everything were covered under a blanket of snow. The advantage of this will be evident to any water works man who has found it necessary to rely on his or his employees' memory for location details.

It is required, of course, in this or any other system, that changes in location of all reference points be promptly adjusted and applied to the records.

The reference books carried in the field consist of photostatic prints in a serviceable cover, and are 12 by 18 inches in size. The tripod is of sturdy construction and can be folded to carry well. The graduated platten is carried in a wooden box which has a separate compartment for the record book.

The cost of making the change complete in our case was approximately $750.00. This includes all labor, material and the entire cost of the first protractor.

No claim for the plan is made except that it appears to meet our requirements satisfactorily. Every water distribution system has its peculiar features, and consideration of them will indicate the best solution of this problem in each case.

(*Presented before the Wisconsin Section Meeting, October 24, 1931.*)

DISCUSSION

C. S. Gruetzmacher (Engineer of Distribution, water works, Milwaukee, Wis.): Mr. Miller is a technical man and the plan he has outlined could only originate in the mind of a civil engineer who has had the experience of locating objects by means of a transit and stadia. He has adapted that method to his everyday work by making it simple so that the layman could use it. It is an old idea made to fit a new condition and its use among waterworks men should be furthered.

It is an exact method, depending, however, for its accuracy upon the stability of its reference points. Should these be moved in any way it would be easy to provide others. Such data could be recorded at the office and the field men supplied in loose leaf form with maps of the entire system of a size easily carried about with them.

Being trained along the lines that Mr. Miller has, I also think that his idea is a good one. In his case, all his "tie ins" were radial, so it would make it easier for his men to adapt themselves to the new method. The transit has always been looked upon by the layman as an intricate instrument and to be used only by the well-trained. It is to Mr. Miller's credit that he had been able to reconstruct the engineer's transit in a simple form fit for a layman's use. The instrument he has built for this purpose is simple as can be, yet its use enables the accurate locating of any valve, etc. and without loss of time. What more can one ask?

Simply this: That it be tried out elsewhere and if found to be useful, adopted as he has. But new ideas are hard to put across, especially this one, and more so where other methods have been in use for long periods of time. I am sure the technically trained men will favor it more so than men of the "old school."

Mr. Miller has spoken of the location record for distribution system, but to my mind he has not fully covered the subject. He has omitted the actual location of the water mains, etc., with reference to something more definite than a reference line between two catch basin covers. I refer to the locating of water mains with respect to the street lines themselves. Should a private utility or even the water company itself intend placing a substructure of any kind in the

street, how would he tell them where the water main is? Surely not by reference to the catch basin covers. That is indefinite for this purpose, albeit it is perfectly accurate to locate valves, etc. for field use. But for construction purposes it is necessary that the main be accurately located with reference to some fixed, permanent location, such as the street lines. This has been our practice in Milwaukee. We are preparing office records, using the quarter-section map of about 30 inches square, scale 1 inch to 100 feet, upon which are shown all mains, hydrants, valves, etc. The mains are referenced to the street lines. It is from these maps that private utilities get their information as to the location of the distribution system. In the office of the Superintendent are placed six large sectional maps of the distribution system. Hereon are shown all mains, hydrants, gate valves, etc. so that the route of the large feeder mains can be seen at a glance. Each map covers an area 3.50 miles north and south and 8.50 miles east and west from the lake to the west county limits. Each map is 4 feet by 10 feet in size. The scale of the map is 500 feet to the inch. Streets with more than one main are widened on the map to permit easy recording of the mains.

For field use of the Superintendent of the Distribution Division and his assistants other smaller quarter-sectional maps of a size 20 inches by 20 inches are being made upon which will be shown all parts of the distribution system and their locations with reference to permanent points upon the streets. This will insure quick shut-offs of gate valves being made, and the small size of the records facilitates their being carried in the field by the crews.

The subject of private and public utility location in city streets in Milwaukee is cared for by having all utilities report all proposed and completed work to the office of the Department of Public Works, and to the Water Department. Before any private utility can obtain a permit to place a substructure in any city street, it must present plans of the proposed work to the Water Department. If the location is found as not interfering with present or future water mains, the plan is approved by the writer and returned to the Department of Public Works, where a permit is granted them. As an added precaution, the city provides an inspector who receives a copy of the approved permit plan and he requires that the utility stay in its proper place.

The rules of the Water Department require that all new work of private utilities such as gas, telephone, electric, etc., be at least three

feet horizontally away from the water mains and two feet vertically in addition. Formerly these utilities placed their conduits, etc. anywhere in the street and as often as not were right above the water main. Such a condition, especially if it be an electric cable of great power, is a danger to workmen of the water department when, in locating leaks, they must drive an iron bar into the ground. Several bad accidents have already occurred. Therefore, it is best that all utilities stay in a predetermined place.

The Milwaukee system of referencing its gate valves consists of painting a cross of about 6-inch length upon the face of curbs, hydrants, poles or any other permanent surface structure in close proximity to the valve being located. The color of the paint is a bright vermillion and these crosses are thus easily found. The distance from the valve to be located is measured at right angles to the face of the nearest curb and the distance is also painted alongside the cross.

Where valves are so located in the intersection of two streets that it cannot be located by any right angled measurement to the nearest straight curb, a cross is painted upon the face of a nearby pole or the curved curb face and the distance measured to the valve from the cross. The cross is placed upon the curved face of the pole or curb so that the direction to the valve is the normal to the tangent of the pole or curb where the cross is placed.

There has been trouble in locating valves which have been covered by snow, dirt or pavements, in that the distances have not been correctly measured. This work is done by the hydrant inspector, They are men who have served their time in the Distribution Department on maintenance and repair work and on account of advancing age have been shifted to the easier work of inspecting hydrants. They are just ordinary laborers who know little if anything about surveying methods and one really cannot blame them for trying to "pace off" distances, or guessing it maybe, than do the more arduous task of measuring distances with a six foot rule.

I, myself, have seen and measured various distances, and have found them inaccurate in some instances. Also in trying to locate a valve from the face of a curved curb, when the valve in question was visible, I have been unable to check the direction to the valve from the cross at the curb where I stood. All of which leads one to think that the ability of the hydrant inspector in determining where a direction is normal to the tangent to the curved face of the curb

or pole is about on a par with his idea that he can guess or pace off distances accurately. Do not think, however, that such discrepancies are in the majority. There are enough of them to indicate that the system is open to improvement.

The city of Milwaukee was a community of 100,000 inhabitants in 1871–72 when the present water works was built and most of its streets were improved with sidewalks, cobble stone or limestone curbs and gutters, and with graded dirt roads. The rule adopted at that time in the location of water mains was to place them 12 feet from the north and the east curb lines of the streets; the gate valves being always placed upon the respective street lines intersecting the line of the water main. Thus it was always easy to find a valve, merely by placing oneself upon the north or east curb, "lining oneself in" upon the street line and then measuring 12 feet and the gate valve would invariably be found thereabout.

But with the passage of years, roadways were widened, additional mains were placed in the same streets, etc., and the curbs from which the original 12 foot distance was measured were set back to another location. Thus disappeared a valuable record. What with whole streets being widened and the multiplicity of underground structures now required by modern city life, the location of a water main cannot be a fixed distance from any curb line, but must be referenced to some more permanent points. Such a point is the street line itself, for it at least is more permanent than the curb line.

The same situation is true regarding the gate valves. These can no longer be arbitrarily set upon the street lines as in former days. The great number of surface and sub-surface structures in the city streets prevent it at times and we must place them either within the intersection or within the block somewhat away from the intersection.

Where several water mains have been laid in intersecting streets, it has been found necessary to place the gate valves in locations other than upon the street lines. Locating these gate valves is then a problem. In our case, as stated before, we tie them in either at right angles to the curb or radially to the nearest curved surface of a likely structure. Thus the locating of a gate valve at a future date is dependent upon the ready finding of the street marks of reference and upon their accuracy in measurement. Much valuable time can be lost and consequent avoidable damage caused due to the disappearance or failure of upkeep of these ready street reference marks.

The larger the water works system the more valuable accurate records become and any newly proposed system which tends to simplify the records of water works location is worthy of trial.

Mr. Miller has outlined to you his new system for locating the gate valves of the water works of Sheboygan. In my opinion it is a good one and merits careful consideration for adoption by others, especially among the smaller cities and towns where the number of gate valves at an intersection is not large. It is a great improvement over the former method in use in Sheboygan in which the valves were located by intersecting arcs. Those of you who are civil engineers know the troubles of trying to locate corner monuments by tie-ins when the reference points have been disturbed or destroyed. You dig up the whole roadway at times and then find it where you least expected.

In order to determine how Mr. Miller's system would work on a crowded intersection in Milwaukee, I have had located by transit angle and measured distance, all the gate valve boxes and manhole covers for aircocks, blow-offs, etc. of the water mains at the intersection of N. Booth St., and E. North Ave., near the Low Service Reservoir. At this point are located in North Ave., two 30-inch mains each connected to the 54-inch main in Booth St. There is a service main in each street or five water mains altogether. There are 29 such locations. It is obvious that if a shut-off be required at any point in this intersection it would have to be done by an experienced man or be under the direction of the Superintendent himself.

No ordinary laborer, even with an enlarged diagram, would trust himself to do it. That has been our experience.

But a diagram of the intersection to a suitable scale and with "tie-ins" to each valve, etc., as was done by Mr. Miller, should enable an experienced operator quickly to locate the valve wanted. One criticism made of Mr. Miller's plan by our Superintendent of Distribution, is that it would not work in Milwaukee because our men have not the ability to use an instrument of that kind, simple as it appears My answer to that is, get some one who can, even if you have to pay more money. There is no reason why uneducated labor should be entrusted with so valuable a work as all water works are.

I intended to survey an intersection of two wide streets but gave it up, realizing that the great distance involved (over 150 feet) would not favor this system. In such a case, several points for reference

should be taken in order to make the survey as simply and quickly as possible when locating the valves.

We intend also to provide our distribution department with location maps for field use. In our case it will take some time and cost plenty money, but when once made, it will be money well spent. Now is a good time to do it. I make a suggestion here that all of you who need such records and intend getting them at some future time, do it now. It will provide jobs for some one out of work. Most water works companies have poor records, if any, of their distribution system and the present depression is a real reason for appropriating enough money to bring all your records up to date.

EXPERIENCES WITH WELL WATER IN AN UNCOVERED RESERVOIR

By K. W. Brown

(*Sanitary Engineer, California Water Service Company, Stockton, Calif.*)

Nothing serves to stimulate and maintain our interest in water purification activities more than the knowledge that there is always a possibility for new and unexpected experiences. Conditions that have been satisfactory for months, or even for years, may change almost overnight and thus bring about what is always a worth while opportunity—that of tackling an unusual problem. Consider, for example, a series of incidents that occurred in an uncovered reservoir at Stockton.

The reservoir to which I refer is a concrete structure having a depth of 20 feet at the overflow level and a storage capacity of 1.8 million gallons. Collapse of the roof in July of last year was not unexpected, nor was it particularly alarming, even though well water in an open reservoir is always conducive to algal development. Control of an iron bacteria infection made it necessary to use copper sulfate in any event, and so there seemed to be no immediate need for a new roof.

TROUBLE WITH BLOOD WORMS

Nothing happened for almost a year. The first summer was unusually warm, but the copper sulfate treatment was effective at all times. Iron bacteria development was controlled as well as ever and there was little or no indication of green or blue green algae. In fact, up until May of this year it appeared as though rebuilding the roof would be an unnecessary expense. But unexpected trouble developed. Following a few complaints about the presence of mosquitoes and worms it was found that the infection originated in the reservoir and that it was undoubtedly attributable to the lack of a roof. Draining, cleaning, and sterilizing was recommended, and the fact that this work was done without delay explains why there was but little trouble in the distribution system.

The appearance of the reservoir when the water was withdrawn was even worse than expected. The walls were literally covered with thousands of silicious deposits which were anywhere from one to two inches long and about one eighth of an inch wide. Examination of several showed that each one was a shelter tube for what is commonly known as a blood worm. This worm, which owes its name to its bright red color, and which was described in recent papers by Bahlman[1] and Hechmer[2] is the larval stage of the aquatic fly Diptera

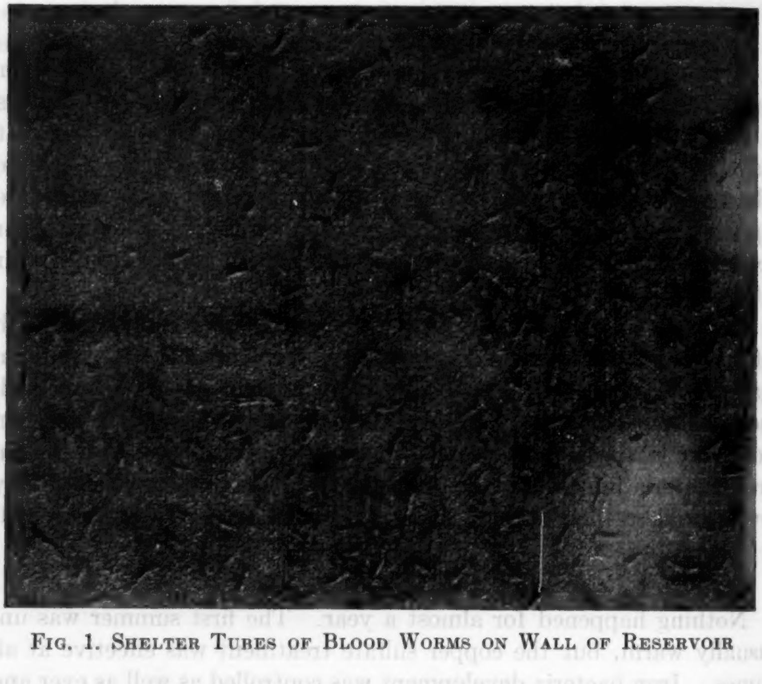


FIG. 1. SHELTER TUBES OF BLOOD WORMS ON WALL OF RESERVOIR

Chironomous. The adult flies deposit their eggs on water and the larvae develop after the eggs become attached to a suitable surface. The larvae, that is the worms, build the shelter tubes and emerge therefrom when ready to develop into the full grown fly, this being similar in size and appearance to the common mosquito.

Another surprising feature was the condition of the bottom of the reservoir. The worms were visible everywhere, and in some places,

[1] Journal, May, 1932, page 660.

[2] Journal, May, 1932, page 665.

especially where there was appreciable slime formation, there were dense masses of squirming bodies. On the other hand, there was no noticeable odor, nor was the slime condition unusually severe or extensive. It seems probable, therefore, that the eggs will develop and prosper even under what would ordinarily be regarded as adverse circumstances.

All those who have reported on experiences with blood worms seem to believe that the only remedy is an insect-tight roof. But before deciding on what should or should not be done, I communicated with Mr. W. C. Purdy, special expert of the U. S. Public Health Service, asking him for information regarding the worm and its characteristics. One of the questions was as to whether there was any possibility of early reinfection, it being emphasized that the reservoir had been drained, thoroughly cleaned, and all surfaces scoured with a strong solution of calcium hypochlorite. His reply, which is of interest in the light of subsequent developments, was as follows:

> " . . . While there seems to be good years and poor years for Chironomous . . . . records indicate that actual troubles occur only infrequently, at intervals of a few years. Also, cleaning the reservoir seems to remedy the trouble. It would therefore seem improbable that your recently cleaned reservoir would become sufficiently infected to make trouble for you again this season."

Because of this opinion, and also because it would be difficult to build a roof under summer load conditions, it was decided to postpone construction until later in the year. Unfortunately, however, reinfection did occur early in September and it again became necessary to clean and sterilize the reservoir. Conditions at that time were bad enough so far as the walls were concerned, but there were fewer worms on the bottom.

The second appearance of the worms was preceded by a month of continuous chlorination, thus proving that chlorine, in normal doses anyway, is likely to be ineffective either as a means of killing the worms or retarding development of the eggs. That this observation is correct was proved by experiments in the laboratory which showed that the lethal dose of chlorine was 50 p.p.m. and that copper sulphate in the same concentration had no effect. Chlorine doses below 50 p.p.m. failed to affect the worms even after a contact period of 24 hours.

Having encountered the second infection, and also having demonstrated by laboratory experiments and actual operating results that

chemical treatment was ineffective, it was decided to take no further chances and to erect a light-tight and insect-tight roof.

TROUBLE WITH IRON BACTERIA

An alarming condition developed several days after the first cleaning of the reservoir. In fact, it appeared as though our efforts were wasted. The originally crystal clear water turned almost black and it became difficult to see more than three or four feet below the surface. On investigation it was found that the discoloration was caused by small particles of amorphous material and that this material contained large numbers of a bacillus form of iron bacteria. This organism, which has been described by Harder,[3] and which also has been the subject of considerable study in our laboratory, is similar to the filamentous forms such as crenothrix, leptothrix, etc. in that it causes the precipitation of iron from solution, even where the iron is present in relatively small quantities. It is this characteristic that was responsible for the deposition in the reservoir and the consequent discoloration of the water.

It should not be assumed that the discoloration was directly attributable to the absence of a roof over the reservoir. While it is true that this was the first time that such a condition was encountered, it is also true that laboratory results showed that the organism developed just as well as in the dark as it did in the light. There is, therefore, no way of proving that an uncovered reservoir was responsible for the discoloration.

In looking around for an explanation as to the cause of the iron bacteria development it was discovered that the copper sulphate treatment had not been resumed. However, even though a decided improvement occurred after three or four applications of this chemical, it was evident that the condition of the water was not entirely satisfactory. The dark color seemed to be eliminated fairly well, but microscopic examinations of material skimmed from the reservoir surface showed the presence of quite a number of diatoms, traces of green algae, and large proportions of amorphous material, the latter being precipitated by the bacillus type of iron bacteria. Another unfavorable condition was that there was an unusually large number of complaints regarding dirty water, although these may have been

[3] "Iron-Depositing Bacteria and Their Geologic Relations," Professional Paper 113, U. S. Geological Survey.

due to conditions caused by cleaning the reservoir rather than to a defect in the quality of the water.

The next step decided upon was that of experimenting with chlorination. Accordingly, arrangements were made to borrow suitable equipment and treatment was started within a few days. In view of what follows it is worth mentioning that the chlorinator was connected to only one of five discharge lines from the well pumps to the reservoir and that the dose had to be adjusted so as to take care of every pump that happened to be in use. This meant that uniform treatment was dependent on thorough mixing in the reservoir.

First results were very encouraging. Objectionable conditions disappeared almost overnight and a great improvement occurred in the clarity and general appearance of the water Furthermore, the amount of material that could be skimmed from the surface of the reservoir was practically negligible, and complaints about dirty water were eliminated almost entirely.

One of the most unusual features of the treatment was the extremely low dose of chlorine required to keep the water in good condition. The applied dose varied between 0.25 to 0.30 p.p.m. and this was effective in maintaining a residual of 0.10 p.p.m. at the reservoir outlet after a contact period of at least 12 hours. Such a result is all the more remarkable in view of the comparatively inefficient facilities for obtaining uniform treatment.

Unfortunately, however, chlorination was not completely successful. Complaints about a medicated taste began to average four or five a day and it became evident that the treatment would have to be improved upon. For this reason, and also because of the absence of a residual in the distribution system, it was decided to experiment with ammoniation.

The ammonia-chlorine treatment was started immediately after the second cleaning of the reservoir. Results so far as clarity and attractive appearance are concerned, were and still are exceptionally satisfactory. In fact, the water looks better now than it has for a number of years, irrespective of whether the reservoir was open or covered.

On the other hand, it must be admitted that no appreciable improvement in the taste condition has been brought about by the use of ammonia. Nor has ammonia been effective in carrying a residual into the distribution system and thus extending the sterilizing action. The taste complaint record has been somewhat better, but it is still

not good enough to prove the necessity of ammoniation. As long as the reservoir was clean to begin with, it seems reasonable to believe that similar results could have been obtained by using chlorine alone.

When the reservoir roof is rebuilt, which will be within the next week or two, we expect to continue chlorination long enough to determine if the benefits thereof are sufficient compensation for the few but persistent complaints about taste. In any event, however, with a new roof the Stockton reservoir will no longer qualify as a habitat for that hardy and prolific pest, the blood worm.

(*Presented before the California Section meeting, October 27, 1932.*)

RATE MAKING, UNDER PRESENT ECONOMIC CONDITIONS

By N. T. Veatch, Jr.
(Of Black & Veatch, Consulting Engineers, Kansas City, Mo.)

Proper rates must meet certain general requirements, among which are:

(1) Provide enough revenue to meet proper operating expenses, depreciation and a fair return on the value of the property.

(2) The rate structure shall be such that every consumer pays his fair share of the total income.

(3) No consumer should receive service for less than cost, for by so doing, discrimination against all other consumers result.

(4) Cost of different classes of service should take into account the "readiness to serve" feature as well as the cost of the product consumed.

(5) Rates should be such as to encourage the use of the product furnished and to do so must make it possible for the consumer to obtain service as cheaply as similar service can be obtained elsewhere.

The above requirements seem simple enough on their face, and they have all been expressed many times in different ways by courts, commissions and authors of numerous papers, books, etc. As a matter of fact, however, the details surrounding every rate case differ, and the application of seemingly simple rules is far from being a simple matter. Under normal times the application of the above rules is fraught with argument and difficulties, and under present economic conditions the situation is considerably worse.

Two main schools of thought have persisted in the field of public service, namely, "Municipal Ownership," and "Private Ownership," each having its following of sincere and honest adherents, and each its quota of those whose motives may not be so styled. The over-zealous advocates of each side make the matter of rate adjustments particularly at this time, more difficult.

The technique involved in rate making is complicated, and many items entering into the matter are subject to honest differences of opinion, and to add the element of extreme partisanship makes the matter even more difficult. Each school has a deep rooted suspicion

of the other, and both are probably right and wrong at the same time. At any rate the seemingly diametrically opposed ideas of public service cause a good many rate controversies to become nothing more or less than "horsetrades." Like most every other question, there is a good and bad on each side. The promotor who develops a property and issues more securities than the situation justifies, and who tries to collect rates that justify such issues, causes suspicion to fall on private ownership generally. The municipal ownership advocate who says municipal ownership should prevail regardless of which plan would give the best and cheapest service to the public discredits municipal ownership. Both examples are extremes.

THE RATE BASE

There are many elements that enter into the making of proper rates, but probably the one of determining the "Rate Base" is more involved and has received more discussion than many of the others. The main items making up the rate base are, valuation of physical property, going value and business development cost, working capital, and materials and supplies. The proper determination of the rate base is important as it determines the annual allowances for interest and depreciation. The exact manner in which the rate base should be determined has never been definitely defined, although the U. S. Supreme Court on January 6, 1930, in the case of the United Railways and Electric Company of Baltimore, vs. Harold E. West, et al., very clearly stated the rule it has followed for many years, "It is a settled rule of this court that the rate base is the present value, and it would be wholly illogical to adopt a different rule for depreciation." This statement evidently means just what it says, which is that the rate base is the present value.

Valuation

The above decision would seem to eliminate the use of investment cost, or historic cost from consideration, as the sole basis of valuation for the rate base, but it does not say that it cannot be considered as an element in determining the present value. As a matter of fact most of the decisions on this point state that all elements of value should receive consideration. A study of most of the decisions indicates that while all elements of value have been considered, undoubtedly more weight has been given to the cost of reproduction than to any other.

It is of interest to note that the use of the term "Cost of Reproduction" first appeared in the case of Smyth vs. Ames an 1898, which case involved the rates to shippers.

William Jennings Bryan was representing the public in this case, and it was he who brought forward the "Cost of Reproduction" theory of determining value. The trend of wholesale prices on commodities from 1801 to the present time is shown in figure 1. At the top of this figure are shown the major causes for the fluctuation in prices. Below the curve is shown the time that different governing

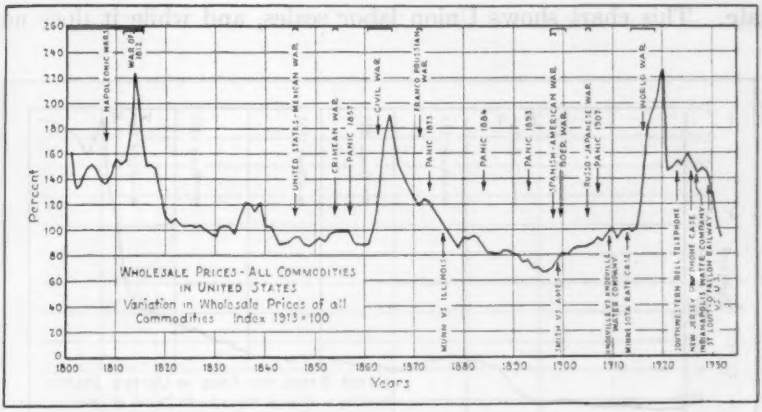


FIG. 1. Data for this chart prior to 1927, were obtained from the February, 1927 issue of the "Monthly Labor Review." Data for years since 1926 were obtained from the February, 1932 issue of the same publication. The February, 1932 data are based on the average for the year 1926 as 100 percent. A factor of 151 percent was applied to the February, 1932 figures in order to get them on the 1913 base. The actual factors show considerable variation from year to year between the two sets of data, the variation between 1913 and 1926 being from 143.3 to 153.9 percent, 151.0 percent being the factor for 1926.

decisions of the Supreme Court of the United States have been handed down. It will be noted that the Smyth vs. Ames Case in 1898 came at a time quite similar to the present. This case reached the Court at a period when price levels were at the lowest point that they have been, either before or since, as is illustrated on figure 1. The period of great activity in railroad construction, beginning immediately after the Civil War, is also shown on figure 1. Prices reached their peak in 1865 and were higher during all of the period of railroad construction down to 1898 when this case was tried. It is

obvious that Mr. Bryan adopted the cost of reproduction theory because that theory would produce a lower value than would the original cost theory.

The development of public utilities, other than railroads, during the past fifteen years parallels closely the picture we have of the railroad development and the decline in price levels. The major part of the public utility construction has occurred in the last fifteen years, all during periods of higher price levels than at the present.

In connection with the study of figure 1, reference is made to figure 2, which shows labor rates per hour, in the United States from 1840 to date. This chart shows Union labor scales, and while it does not

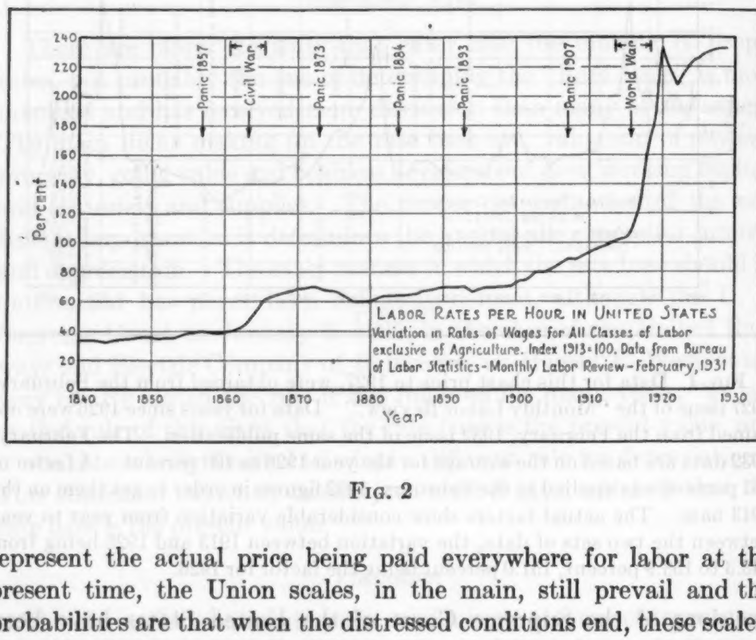
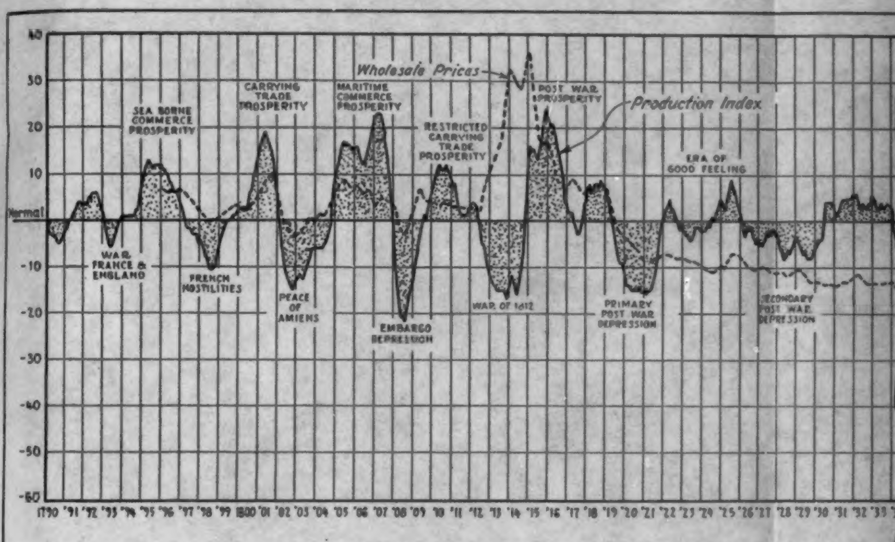


FIG. 2

represent the actual price being paid everywhere for labor at the present time, the Union scales, in the main, still prevail and the probabilities are that when the distressed conditions end, these scales, or scales slightly modified, will prevail. Referring again to figure 1, it would appear that the price trend in the future will be on a gradually ascending scale until we reach some major cause for inflation.

The application of this study of price trends to the matter of rate making has its connection in the determination of prices used in making the valuation. It is not believed that the term "present value" in any sense means "spot prices" as of one particular date; but rather a value that would be considered a fair value in step with


Wholesale Prices
Production Index
Normal
SEA BORNE COMMERCE PROSPERITY
WAR FRANCE & ENGLAND
FRENCH HOSTILITIES
CARRYING TRADE PROSPERITY
PEACE OF AMIENS
MARITIME COMMERCE PROSPERITY
EMBARGO DEPRESSION
RESTRICTED CARRYING TRADE PROSPERITY
WAR OF 1812
POST WAR PROSPERITY
PRIMARY POST WAR DEPRESSION
ERA OF GOOD FEELING
SECONDARY POST WAR DEPRESSION
40
30
20
10
-10
-20
-30
-40
-50
-60
1790 '91 '92 '93 '94 '95 '96 '97 '98 '99 1800 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11 '12 '13 '14 '15 '16 '17 '18 '19 '20 '21 '22 '23 '24 '25 '26 '27 '28 '29 '30 '31 '32 '33

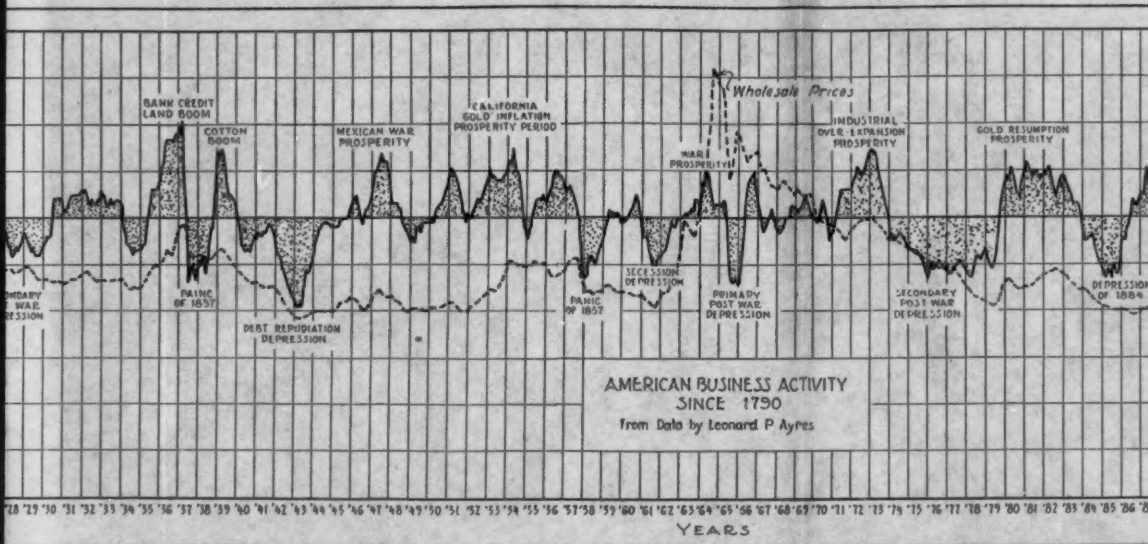
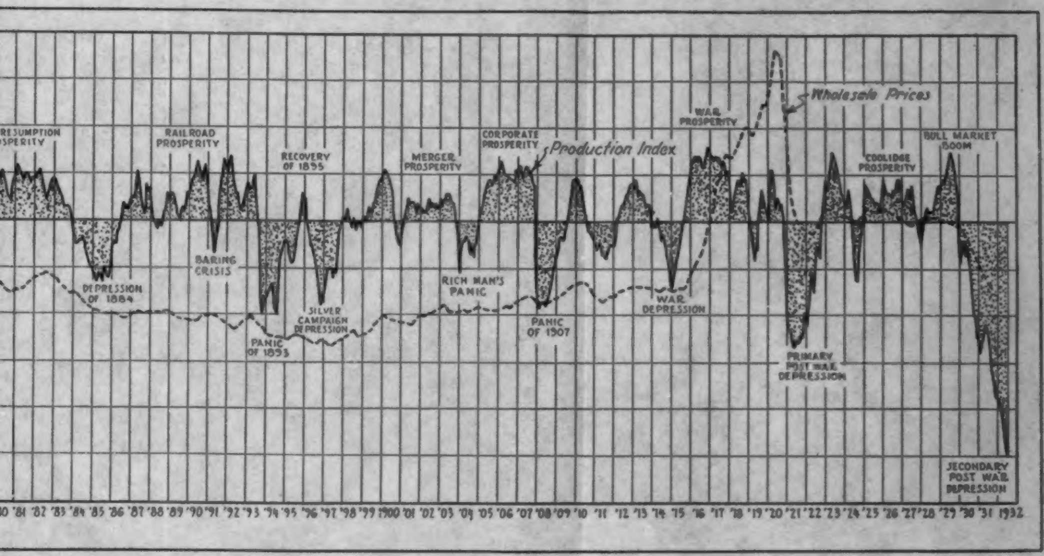

BANK CREDIT LAND BOOM
COTTON BOOM
MEXICAN WAR PROSPERITY
CALIFORNIA GOLD INFLATION PROSPERITY PERIOD
Wholesale Prices
WAR PROSPERITY
INDUSTRIAL OVER-EXPANSION PROSPERITY
GOLD RESUMPTION PROSPERITY
PANIC OF 1837
DEBT REPUDIATION DEPRESSION
PANIC OF 1857
SECESSION DEPRESSION
PRIMARY POST WAR DEPRESSION
SECONDARY POST WAR DEPRESSION
DEPRESSION OF 1884
AMERICAN BUSINESS ACTIVITY SINCE 1790
From Data by Leonard P Ayres
YEARS

Fig. 3


RESUMPTION
SPERITY
RAILROAD PROSPERITY
RECOVERY OF 1895
MERGER PROSPERITY
CORPORATE PROSPERITY
Production Index
WAR PROSPERITY
Wholesale Prices
COOLIDGE PROSPERITY
BULL MARKET BOOM
DEPRESSION OF 1884
BARING CRISIS
PANIC OF 1893
SILVER CAMPAIGN DEPRESSION
RICH MAN'S PANIC
PANIC OF 1907
WAR DEPRESSION
PRIMARY POST WAR DEPRESSION
SECONDARY POST WAR DEPRESSION
'81 '82 '83 '84 '85 '86 '87 '88 '89 '90 '91 '92 '93 '94 '95 '96 '97 '98 '99 1900 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11 '12 '13 '14 '15 '16 '17 '18 '19 '20 '21 '22 '23 '24 '25 '26 '27 '28 '29 '30 '31 1932

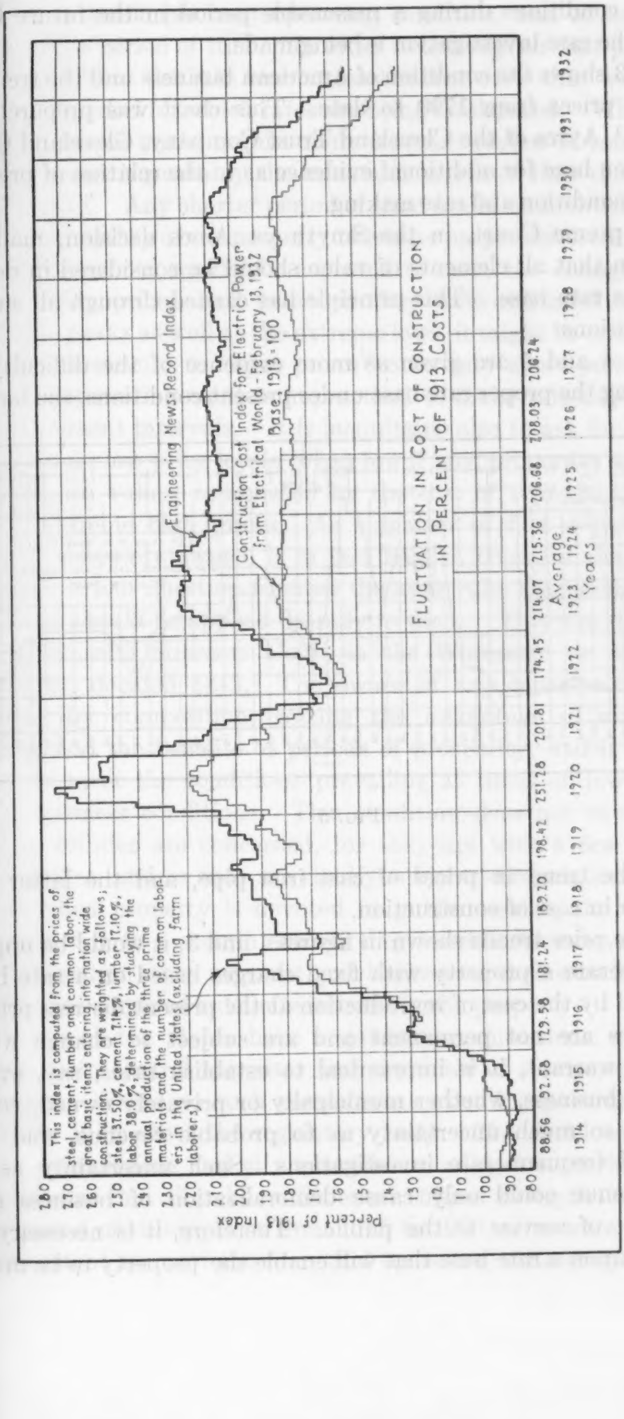

FLUCTUATION IN COST OF CONSTRUCTION
IN PERCENT OF 1913 COSTS
Engineering News-Record Index
Construction Cost Index for Electric Power
from Electrical World - February 13, 1932
Base, 1913 = 100
This index is computed from the prices of steel, cement, lumber and common labor, the great basic items entering into nation wide construction. They are weighted as follows: steel 37.50%, cement 7.14%, lumber 17.10%, labor 38.07%, determined by studying the annual production of the three prime materials and the number of common laborers in the United States (excluding farm laborers)
Percent of 1913 Index
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
Average
88.56
92.58
129.58
181.24
189.20
198.42
251.28
201.81
174.45
214.07
215.36
206.68
208.03
206.24
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
Years

FIG. 4

economic conditions during a reasonable period in the future from the time the rate investigation is being made.

Figure 3 shows the condition of American business and the trend of wholesale prices from 1790 to date. This chart was prepared by Leonard P. Ayres of the Cleveland Trust Company, Cleveland Ohio, and is given here for additional evidence as to the relation of present economic condition and rate making.

The Supreme Court, in the Smyth vs. Ames decision, made it quite plain that all elements of value should be considered in determining the rate base. This principle has carried through all subsequent decisions.

Figures 4 and 5 are given as more evidence of the difficulty of determining the proper rate base under present conditions, the former

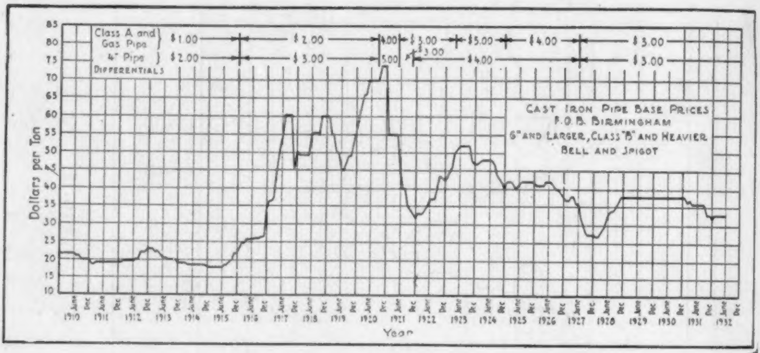


FIG. 5

showing the trend in prices of cast iron pipe, and the latter the fluctuation in cost of construction.

With the price trends shown in figures 1 and 3, it would be impossible to operate a property with fixed charges based on a rate base determined by the cost of reproduction at the present distress prices. While rates are not permanent and are subject to change when conditions warrant, it is impractical to establish rates, say, every year. No business, whether municipally or privately owned, could exist with so much uncertainty as to probable revenue, and the expense of frequent rate investigations. Such uncertainty as to future revenue could only cause demoralization of business and impairment of service to the public. Therefore, it is necessary to determine upon a rate base that will enable the property to be main-

tained in a 100 per cent operating condition, and to do so over a reasonable period of time. In order to accomplish that purpose, it is necessary that the rate base at least reflect costs that would prevail over the period for which rates are being established. While extreme circumstances might require more frequent review of rates, a period of five years is probably the minimum length of time that should be considered. Any shorter period of time would undoubtedly seriously affect the ability of the property to render proper service to the public.

If rates could readily be adjusted to meet the changing trend of commodity prices, and provided they were adjusted to meet the extreme peaks as well as the extreme lows, it might be entirely proper to adhere strictly to "spot prices" over very short periods. However, as stated above it is impractical to make rate adjustments at such frequent intervals. It is inequitable also to ask for rates based on extreme low price levels, when few if any properties were allowed to earn on values established by the cost of reproduction method using extreme high prices. As a matter of fact a public utility, even if privately owned, is in fact held in trust for the public and there is serious question whether the same rules that govern ordinary business should be applied literally to them. This was stated by the Massachusetts Supreme Court in the Worcester vs. the Western Railroad, decided 1842. The owner of any business is regulated mainly by competition, getting the advantage of extreme high prices, and the benefits of periods of prosperity, and it is expected that he meet the conditions prevailing at times of low prices and poor business conditions. This condition does not exist as far as public utilities are concerned, for they are with a few exceptions, monopolies, and as such are rightly subject to regulation. Furthermore when property is devoted to public service, the owners lose control of it to a certain extent; they must serve everyone without discrimination; they may not quit business at their own free will; the public has acquired a definite interest in the property.

Many of the states have regulatory commissions, the duty of which is to control the rates and character of service, of all public utilities. Where no such commissions exist the governing body of the city is in effect the regulatory body. The decisions from both state commissions and city councils are subject to review in court. This means that all public utilities are subject to regulation. During the period of rising prices from 1915 to 1920, rates were adjusted to some extent to meet the increased operating costs and to give con-

sideration to the increased cost of reproduction. Prices at either high or low extremes, however, should be tempered. A rate base, under present distress conditions must be tempered by other considerations than present prices if equity is to prevail.

There is a serious situation confronting public utility properties at the present time, especially those where a large proportion of their property was installed during periods of high prices. If rates are established on the basis of extreme low prices a large part of the money invested will be literally wiped out. Let it be understood that actual value is being discussed, and not the amount of outstanding securities. Perhaps an illustration might make this point clearer. Let us consider some unit in a utility property that at time of installation cost \$100.00, and that the same unit can be purchased at this time for \$75.00. If a rate base based on the cost of reproduction at present prices was adopted, interest and annual allowance for depreciation according to the decision of the Supreme Court would be based on the \$75.00 value. The "annual depreciation allowance" is a sum set aside each year for the purpose of taking care of replacements and renewals, obsolescence, inadequacy, wear and tear, etc. Its primary purpose is to protect the integrity of the dollar invested, so that at the end of the useful life of any unit of the property, money will be available to replace it. If no provision is made for depreciation, the original investment would gradually be dissipated. Now if the annual depreciation allowance is based on the \$75.00 price, 25 percent of the original investment will be lost. Just how far public utilities, regulated as to return, should be forced to liquidate their capital accounts, is a question that must be solved. This question applies to both publicly and privately owned properties, for the fairness of rates to the public must be considered as carefully in the one case as the other.

There are indications that some of the privately owned utilities will content for original cost, as a basis for the rate base. To follow such a plan would involve a number of difficulties on which the Supreme Court has already expressed itself. Such matters as "piece meal" construction, "prudence of investment," etc., will have to be taken care of. While it is patent that the privately owned utilities have been developed for the purpose of earning money and as much as possible, it is also true that they have had to make large investments at times of high prices in order to meet the demands of the public for service. This is also true of municipally owned properties.

Whether or not from the very nature of things, due to the fact that the interests of the utilities and the public really go hand in hand, large investments of both public and private capital shall be dissipated, is the point at issue. Fortunately no court or commission decisions are on record in such a way as to preclude the establishment of a rate base, based upon the determination of a "fair present value." It may be that the cost of reproduction theory, with prices selected to represent a fair level, will become an important element for consideration in determining the rate base. At any rate it is evident that great care must be exercised in making valuations for rate making, under present conditions.

Going value and development cost

Going value and development cost is another item entering into the determination of the rate base. This item of value represents the difference in value between a property complete and ready to operate, but with no connected business, and one complete and operating with business connected. It has been variously defined, and variously calculated. It is truly an intangible item, its value cannot be calculated as the cost of the different units making up the valuation. It represents money invested as capital, either direct or from decreased earnings. There are many things to be considered in determining going value, among them being the cost of obtaining customers the cost of developing an operating personnel, the cost of perfecting adequate records, maps, etc. In years past attempts have been made to determine going value from either earnings or lack of them. To base the value on earnings, is merely penalizing the customer for a condition brought about by the rates paid. To base the value also on early losses is wrong as it reaches an absurdity when the plant showing the poorest results would have the largest going value. There is a decided tendency in determining this value to give considerable weight to the cost of developing the business, leaving out the matter of earnings entirely as they are governed by the rates charged and could be easily changed. The term "Going Value" has been confused with "Good Will" in the sense that it would be applied to a mercantile business, and the term "Development Cost" more nearly describes what is intended. Generally this element of going value may be construed as the cost of converting a completed but dormant plant, into a "going concern" with business attached, trained operating personnel and earning money.

Going Value or Development Cost is not a depreciable item, and hence does not enter into the matter of annual depreciation allowance, but it does affect the return. Therefore, the determination of this item of value must be made with due consideration of price trends. Here again the present economic conditions made the task more difficult.

Working capital

Working Capital is clearly an item belonging in the rate base, as the money so tied up represents an item of capital account as much as the money spent for physical items. Salaries, monthly bills, etc., must be met promptly, and cannot wait for collections to come in, which fact requires a certain amount of idle money, so far as interest is concerned. It is variously estimated from one-twelfth to one-sixth of the total yearly operating expense. The determination of the proper amount to allow for working capital must be made after conditions prevailing in each particular case are known. It is a non-depreciable item, and is based on operating costs which, of course, vary with economic trends.

Materials and supplies

The item of "Materials and Supplies" belongs in the rate base, as considerable money is always tied up in this account. It is useless to discuss the need for or the reasonableness of this item. The amount is usually taken from the actual cost of stocks on hand, and in this way does not present the same difficulties in regard to adjustment to economic conditions as do many other items. However, the prices used in determining the value should in reality receive the same consideration as those used in the valuation of physical property, for rates based on an inventory of materials and supplies priced at extreme low levels, would be inadequate under higher prices.

OPERATING EXPENSES

Proper rates must furnish enough money to pay all operating costs, such as fuel, salaries, rentals, transportation, etc. These costs can be obtained by audit of the records. No rate case should be gone into without the assistance of a capable accountant, experienced in public utility matters. Here again the total amount of these expenses is directly affected by economic changes, and should be tempered accordingly in establishing a rate covering a period in the future.

FIRE PROTECTION

While it has been the purpose of this paper to discuss mainly the difficulties the present economic condition imposes upon rate making, it is perhaps pertinent to discuss the element of rates known as "readiness to serve." One of the best examples of this feature is the element of fire protection in the field of water works. There is probably no feature of rate making in the water works field that gets less careful analysis and thought. The percent of cost of entire plant chargeable to fire protection as estimated by Metcalf, Kuichling and Hawley, in their excellent paper entitled "Reasonable Return for Fire Hydrant Service," (Journal A. W. W. A., 1911) is as follows:

Population	*Percent*
5,000	77
10,000	60
50,000	32
100,000	23
300,000	13

The amount of water actually used for fire protection is usually a very small percent of the total water pumped, and it does not matter much whether it is taken into account. However, fixed charges are needed for the added investment required to give fire protection, and those receiving this protection should pay for it. This cannot be equitably done through water rates, hence the fire hydrant rental. Investigation shows that charges for this service varies from zero to as much as $100.00 per hydrant per year. Strictly speaking this cost of fire protection should be paid for by those having inflammable property, and perhaps in proportion to the values of the different properties. This would be very difficult to determine and the small injustice to the owner of vacant land, by the payment through general taxes for hydrant rental, is probably offset by the enhancement of value of his property due to presence of fire protection. At any rate every operator of water properties should analyse his situation and see whether or not this element of fire protection is being taken care of. The only place where no hydrant rental would be justified would be a city where every one was a consumer, and where the amount of water used bore the same ratio to others as his property did to other property. This never exists. Some of the smallest consumers have the largest fire hazards.

OUTSIDE CONSUMERS

One other item worthy of consideration by water works officials is that of charges to consumers living outside the city limits. Apparently the cities that charge extra for this service and those who do not are about equally divided. There is one case, the City of New York, where the charge is less, but its situation is unique in that the city acquired all readily available water supplies nearby, thus cutting off supplies of suburban areas. It appears that some differential should be charged for this service. It can be done in different ways, either in connection with plan of main extensions or in the rates, or probably better in both ways. The State of Ohio has a law requiring a charge of 10 percent in excess of rates within the city limits. There are cases, of course, such as large consumers, where competitive conditions would prevail, and the added business would justify lower rates. However, it would seem that no incentive should be given by the city to cause people to live outside the city.

Reverting to rate making generally, there is one element that deserves mention. There has been some criticism of courts and commissions on matters of rate adjustment, which in the main has been unjust. Most of the regulatory bodies are made up of sincere and capable men, doing their best under the circumstances. It is necessary that their decisions be based on facts rather than argument, and in the majority of cases it is often necessary for the commission to do all that is done in the way of preparation of data for the public side of the case. What often happens is that the cities file a complaint with the commission, and then do very little to prepare a case. The City Attorney will do his best in argument, but he should have the technical assistance needed properly to press his side of the case. The situation is somewhat analogous to filing a case in court and then doing nothing more than appear for argument. In some cases the commissions have sufficient staff to collect a certain amount of data, but the cities would be much better off if their side of the case were backed up by all necessary data and testimony of their own. As stated the Courts and Commissions must decide the case on facts and not argument, and criticism is unjust if definite data are not presented to them for their consideration.

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UNUSUAL FEATURES OF THE RODRIGUEZ DAM CONSTRUCTION

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The Rodriguez Dam is situated on the Tijuana River, in the northwestern part of Baja California, Mexico, about 11 miles easterly from the town of Tijuana. Its purpose is the storage and diversion of water for the irrigation of about 5000 acres in that part of the Tijuana valley which lies in Mexico, and for the domestic supply for the municipality of Tijuana, now having a population of about 10,000.

The drainage basin of the Tijuana River, which lies partly in Baja California and partly in San Diego County, California, has an area of 1670 square miles, which is greater than that of any other stream south of Los Angeles and west of the Colorado River, and nearly equals the total area of the drainage basins of all other streams lying in San Diego County. The stream has two branches, upon the larger and more southerly of which the Rodriguez Dam is being constructed. The area of the drainage basin above the Rodriguez site is 938 square miles, which about equals the total area tributary to the lowest storage sites on the Otay, Sweetwater, San Diego and San Dieguito Rivers, San Diego County.

Like all streams in the vicinity, the flow of the Tijuana River, in most years, is very small and the supply necessarily is dependent upon the storage of flood waters. Periods of from five to seven years, during which the flow is insignificant, may be expected, and consequently large carry-over storage is necessary. In order to furnish a sufficient irrigation and municipal supply, it is necessary to construct a reservoir having a capacity of 110,000 acre feet, or 36 billion gallons. A reservoir of this capacity, even though empty at the beginning of the rainy season, would have been filled in 1916, 1922, 1927 and 1932. The reservoir will have a safe yield of about 8900 acre-feet, or 3 billion gallons per annum, an average yield of 8 million gallons per day. It will have an area of 2240 acres, and a length of about $4\frac{3}{4}$ miles.

While streams in this vicinity ordinarily have very small flows,

even during the rainy season, excessive floods sometimes occur. The largest flood of definite record was that of 1916. At that time the flow of the Tijuana River, a short distance below the Rodriguez damsite, was about 70,000 second-feet. A study of the flows of streams in San Diego County, during the flood of 1916, leads to the conclusion that at Rodriguez damsite a flood of 150,000 second-feet is possible.

The dam is situated in a gorge having a minimum width at stream bed of about 100 feet, and at 130 feet above stream bed, a width of about 750 feet. Above this, the site is flanked by gentle slopes. Rock outcrops throughout the greater part of the site. The rock of the canyon walls, that of the western slope, and that of a portion of the eastern slope, is ryolite, while that of the eastern part of the eastern slope is granite. The outcrop of the contact between the granite and the ryolite crosses the stream bed a short distance above the damsite and is clearly seen where it intersects the westerly bank of the river. The rock is fused along the contact, showing the granite to be intrusive, and indicating that no great amount of leakage from the reservoir may be expected along the contact. The surface rock generally was much broken and in many places disintegrated, so that a large amount of excavation was necessary in order to obtain suitable foundation.

In 1927 and the early part of 1928, a preliminary investigation of the Rodriguez damsite, then known as the García site, was made by the writer, then employed by the J. G. White Engineering Corporation, which company, under a contract with the National Commission of Irrigation of Mexico, was engaged in the investigation, design, and construction of irrigation works in that country.

In the preliminary investigation of the damsite, nine borings were made in the stream bed and 52 test pits were excavated on the side hills. Five of the 9 borings in the stream bed indicated satisfactory rock at depths not exceeding 50 feet. From 4 of the borings, no cores could be obtained and 2 of the 4 indicated disintegrated material. For comparative estimates, preliminary designs were made for alternative types and heights of dam, including multiple-arch, single-arch with gravity wings, gravity, and rock-and-earth-fill types.

At this time, so far as known, no geologic investigation of the site had been made. In reporting his investigations to the J. G. White Engineering Corporation, the writer stated that he considered it

essential that an examination be made by a competent geologist before selecting the site for the dam, or the type of structure. He stated further that in view of the conditions indicated by the borings, it was his opinion that, of the preliminary designs which had been submitted, the rock-and-earth-fill dam would most nearly meet the requirements for a dam at the García site.

A geologic examination of the site, an inspection of the test pits and of the cores and wash-samples from the borings, and a general reconnaissance of the adjacent territory, both in Mexico and the United States, made by the Consulting Geologist of the National Commission of Irrigation, was begun January 25 and completed early in February, 1928. The geologist expressed the opinion that suitable foundation for a concrete dam could be secured in the stream bed and the greater part of the side hills, but that, in his opinion, a rock and earth-fill dam should be adopted for a part of the dam on the eastern slope.

On Feburay 27, 1928, the Territorial Government entered into a contract with the Ambursen Dam Company of New York for the construction, at the García site, of a dam of the Ambursen type. Excavation in the stream bed was begun in May, 1928. Bed rock was encountered at several points near the upstream limit of the excavation at about 35 feet below the original stream bed. The rock was of poor quality and not suitable for foundation. The excavation revealed a geologic fault about 20 feet in width extending along the easterly margin of the stream bed.

After the excavation had been carried to a sufficient depth to expose the rock of the entire upstream part of the foundation site in the stream bed, and after a cut-off trench along the extreme upstream limit of the foundation had been excavated to a depth of some 12 to 15 feet, showing clearly a cross-section of the materials, Mr. A. J. Wiley (deceased), M. Am. Soc. C. E., Dr. F. L. Ransome, Consulting Geologist, and Dr. Paul Waitz, Consulting Geologist for the National Commission of Irrigation of Mexico, were called for consultation regarding the suitability of the site for the construction of a dam of the type and height proposed. The problems considered were the practicability of obtaining suitable foundation for the dam, the possible danger from future seismic disturbance, and the possibility of excessive leakage from the reservoir, either under the dam or through the side hills. The geologists agreed that the fault is apparently not active, that, while the existence of the fault is objectionable,

the risk involved is not sufficient to justify condemnation of the site, and that the engineers could take such precautions as will make the chances of failure small, although they cannot be entirely avoided. It was their opinion that leakage through the side hills would not be excessive. The provision of a sufficient support for the dam in the stream bed, and the control of percolation under the dam at the fault, were considered by the geologists to be problems to be handled by the engineers.

THE AMBURSEN TYPE OF DAM AND ITS ADAPTATION TO THE SITE

Several Ambursen dams have been built in California, the principal one being the Stony Gorge Dam, built for the U. S. Bureau of Reclamation on the Orland Irrigation Project. The Ambursen type of dam is similar to the multiple arch dam, flat reinforced concrete slabs being substituted for the arches of the latter type. The flat slabs are not rigidly attached to the supporting buttresses, but merely rest on haunches, or brackets, projecting from the buttress faces.

There has been some criticism of the type of dam selected for the Rodríguez site, and also of the construction of a dam of any type at the site. Most of the criticism has been by non-technical critics, and some very erroneous statements regarding the work have been made by the local non-technical press. However, differences of opinion, even among well qualified engineers, are common in connection with the construction of storage dams, particularly those of magnitude. So far as known to the writer, only one engineer of prominence has expressed disapproval of the construction of a dam at the site, or of the type of dam selected. Since the writer had no part in the selection of the type of dam chosen, and was not even present at the time of its adoption, he has no positive knowledge of the reasons actuating its selection and his comments are based wholly upon his subsequent personal consideration and his conferences and discussions with consulting and other engineers connected with the work or acquainted therewith.

The building of any reservoir dam is a serious responsibility, especially one in a country subject to earthquakes and at a site traversed by a geologic fault. It, of course, would be desirable to avoid the construction of a large reservoir under such conditions. However, as a country develops, the storage of water becomes a necessity. Particularly in the arid and semi-arid regions, the full

utilization of the available water supply is essential to the highest development of the country. If the region is one subject to earthquakes and traversed by faults, the necessity for storage is none the less imperative. The construction of storage dams at the best, or least objectionable available sites, becomes as much a necessity as the building, or rebuilding of a city under similar conditions. The question becomes whether the risk is too great to justify continued development, and if not, what types of buildings and other structures shall be built in order to give the greatest practicable insurance against damage.

The principal types of dam which were, or might have been considered in connection with the Rodríguez site are as follows: rolled earth-fill, rock-fill, hydraulic-fill, or any combination of these three types, and concrete dams, including the gravity, single arch, multiple-arch, round head buttress, and Ambursen types, or any combination of these.

As before mentioned, the writer recommended to the J. G. White Company, at the time of the preliminary examination, a rock and earth fill dam. This recommendation was based on the presence of disintegrated material extending to a great depth in the stream bed, as indicated by the borings, and without knowledge of the presence of a geologic fault. However, Mr. A. J. Whiley, than whom there was no higher authority on dams and their foundations, called attention to some very grave dangers to which a dam of this type would have been subject: first, that of having the partly completed dam destroyed by a flood in excess of any practicable conduit capacity during construction and before the dam had reached the spillway level, and second, should movement along the fault occur when a considerable amount of water is in storage, the probable failure of a large part of the dam by admission of water into its mass through cracks, or by overtopping due to subsidence of the embankment. The objections to a rock-fill dam apply with equal or greater force to a rolled earth-fill, or an hydraulic-fill dam.

In the case of a multiple-arch dam, the stability of the dam, as a whole, depends upon the integrity of each individual arch. The failure of one arch would result in the collapse of the structure. A small movement along the fault would probably be followed by total failure. Any type of arch dam, except a gravity-arch, probably would collapse should there be any material slip along the fault. The generally inferior quality of the rock in stream bed renders the use of a gravity dam impracticable.

The Ambursen dam is more flexible than any other type of concrete dam, and small relative movements can occur without resulting in serious torsional stresses. For this reason, this type of dam was selected by the U. S. Bureau of Reclamation for the Stoney Gorge site, through which extends a geologic fault. In the Ambursen dam as designed for the Rodríguez site, the buttresses are connected in pairs by diaphragm walls, for the purpose of securing greater lateral stability. Adjacent pairs are not attached, but are merely braced by means of struts, supported in sockets in the buttress walls. In a dam of this type the failure of one or more spans would have no effect upon the remainder of the structure, except by progressive undermining by the escaping water. The dam might be even torn apart, but the separated sections would still stand and hold back, to a considerable extent, the escaping water. Although he had no part in the selection of the Ambursen type of dam for the Rodríguez site, it was Mr. Wiley's opinion that no better type could have been selected.

DESCRIPTION OF RODRÍGUEZ DAM

The maximum height of the Rodríguez dam is 187 feet above stream bed and about 240 feet above the lowest part of the foundation. The length will be about 1900 feet. The spacing of the buttresses is 22 feet, center to center. Their thickness varies from 19 inches at the top to 66 inches at the base of the highest buttress. The thickness of the deck varies from 25 inches at the top to 64½ inches at stream bed. The lower face of the deck has a slope of one to one, and the downstream face of the buttresses a batter of 5 vertical to one horizontal.

In each of three stream bed bays of the dam, there will be a 5 foot by 5 foot sliding sluice gate, operated by an hydraulic cylinder. The service outlet works will consist of two 30 inch cast iron pipes, at an elevation of about 30 feet above stream bed, in each of which will be installed a 30-inch by 24-inch Johnson needle valve, and two 30-inch emergency gate valves. Below the valves, the pipes will merge into one 36-inch cast iron pipe. The discharge will be measured by a venturi meter.

The spillway, which will be in the west wing of the dam, will be controlled by nine 30-foot by 30-foot steel gates on caterpillar bearings, and will have a capacity of 150,000 second-feet.

The Rodríguez Dam is of special interest for several reasons:

(a) It is much higher than any dam of the Ambursen type heretofore built, and some of the details of buttress construction have not been used heretofore;

(b) The four buttresses in stream bed, where the foundation is of inferior quality, are supported by a concrete arch, of strength sufficient to support the entire superimposed load and transmit it to the solid rock forming the canyon walls; and

(c) At the fault, the principal cut-off wall will extend to a depth of 300 feet below stream bed, and is being built from the top downward, by means of shafts.

In the construction of a buttressed dam, it is important that cracking of the concrete in the buttresses be avoided. The buttresses can be constructed conveniently only in approximately horizontal sections. Even in a dam of moderate height, the lengths of the lower sections between the upstream and downstream limits are relatively great. In long sections, volume changes, due principally to the loss of the heat of hydration and to the loss of contained water, result in cracks which extend usually in a direction nearly normal to the direction of maximum length. Cracks in horizontal sections, therefore, will usually extend in a nearly vertical direction, which, for most parts of a buttress, is nearly the direction of maximum shear. Cracks in the direction of maximum shear particularly are to be avoided.

The tendency to crack can be reduced by reducing the length of the sections, that is, by dividing the full length sections into blocks by means of construction joints. Obviously, a vertical construction joint, particularly if relatively smooth, would be as objectionable as a vertical crack. However, construction joints can be inclined, so as to extend along planes of no shear at full load and shear of minor intensity at reduced loads; also interlocking keys to resist shear can be constructed in the adjacent blocks. In recent years, several dams have been built with continuous construction joints, located along the lines of maximum principal stress at full load, along which, at full load, there will be no shear. Notable among such are the Big Dalton Dam and the Coolidge Dam. Such joints virtually divide the buttress into a set of curved columns more or less independent. A structure of such type, if correctly designed and properly constructed, undoubtedly would be structurally sound, provided the integrity of the individual columns is maintained. If the columns are constructed in horizontal blocks, vertical cracks may occur in one or more of the blocks, which might seriously impair the integrity of the column,

unless the blocks are sufficiently reinforced against the maximum shear. Many engineers are not fully satisfied with the subdivision of buttresses into a set of curved columns, believing that a monolithic buttress is preferable.

The buttresses of Rodríguez dam are now being constructed with an arrangement of construction joints and reinforcement not heretofore employed. These joints are continuous and follow the trajectories of the maximum principal stresses at full load. They are, however, arranged in pairs, and each horizontal section is subdivided into short and long blocks, the short blocks being about 5 feet long and the long blocks not exceeding 40 feet in length, and usually not more than 35 feet. The buttresses are reinforced throughout with bars parallel to the deck, thus being inclined at an angle of 45 degrees with the horizontal. The bars are lapped in the 5 foot blocks, which are constructed not less than 30 days after the construction of the longer blocks. The longer blocks, therefore, have not less than 30 days in which to cool and shrink, before being rigidly attached to adjacent blocks. When the 5 foot blocks are constructed, the buttress becomes virtually monolithic.

Another detail of construction, used in this dam and not heretofore employed in Ambursen dams, is a device for preventing the downward movement of the deck beyond the position occupied during construction.

In computing the stresses in buttresses in Ambursen dams it has been the custom to assume that the entire weight of the deck is transferred to the supporting buttresses, constituting a downward vertical load. The deck merely rests upon the supporting buttress haunches, or brackets, and an asphaltic mastic is applied to the seat upon which the deck rests. If it be assumed that the deck may creep downward, then eventually only the component of the weight normal to the seat would be carried by the buttress, the component parallel to the seat being carried by the foundation. The reduction of the load carried by the buttress would affect the buttress stresses materially. If the minimum principal stresses were tension, the tension would be increased.

In the case of the approved design for Rodríguez Dam, the greatest computed tension in buttresses is 78 pounds per square inch. If the deck were free to creep downward, the greatest computed tension would exceed 150 pounds. Downward creeping of the deck is prevented by the very simple device of keyways constructed in the

buttress tongue, against which the ends of the deck abut, these keyways extending in a direction normal to the haunch seat upon which the deck rests.

When the reservoir is empty, the deck, being exposed to the sun, may become heated to a much higher temperature than the buttresses, which are protected. The deck then will expand and will tend to creep upward. This might result in excessive shearing stress in the keys and tension in the upstream portion of the buttress. To avoid this, strips of cork-wood are inserted in the keyways along the upper edges. These strips have a thickness of one inch, for a vertical distance of 135 feet above the base of the buttress, and 1½ inches, where the distance exceeds 135 feet.

THE FOUNDATION STRUCTURE

The bearing power of the rock in the stream bed differs greatly in different parts of the foundation area. Four of the buttresses, had they been founded on natural material, would have rested, for a portion of their lengths, upon material of relatively poor bearing power. Two of the four would have been founded, for a part of their lengths, upon the material of the main fault. It was evident that it would be necessary to support the four buttresses by a structure of such type that the loads, which would have been borne by the weaker parts of the foundation area, would be transferred to those parts having ample supporting power. Preliminary designs were made of several types of foundation structure. The type finally selected consists of a continuous arched barrel, superimposed upon massive articulated blocks of concrete, extending from the intrados of the arch to the natural rock of the stream bed. Owing to the varying section of the stream bed, the arch barrel varies in cross-section. The length of span varies from 79 to 95 feet, the rise from 26 to 28 feet, the crown thickness from 6 to 7 feet, and the haunch thickness from 9 to 10 feet. The arch is designed to carry the full superimposed load. It is expected, however, that a considerable part of the load will be supported, through the sub-intradosal concrete blocks, by the natural material of the stream bed. Where, however, the natural material has not supporting power sufficient for the entire load, and incipient settlement results, a portion of the load will be transferred to the arch, thus relieving the natural material of such part of the load as may be necessary to prevent further settlement.

Before beginning the construction of the sub-intradosal blocks

transverse cut-off trenches 2 feet wide and 3 feet deep, spaced 25 feet, center to center, were excavated in the fault zone and in the adjacent rock, where of inferior quality. The stream bed was then covered with a concrete mat, not less than 2 feet in thickness. Transverse key-ways where constructed in the upper surface of the mat, to prevent sliding of the superimposed structure.

The sub-intradosal concrete was constructed of interlocking blocks. The upper surfaces of the blocks, upon which rests the arch barrel, were finished smooth and coated with oil, to prevent adhesion. Transverse keys, 6 inches deep and 10 feet wide, were constructed in the tops of all blocks, to prevent sliding of one course upon another, or sliding of the arch upon the blocks.

At the time of a large flood, the depth of water on the crown of the arch may be as much as 15 feet. The water load on the extrados of the arch would be considerable unless counterbalanced by water pressure on the intrados. Ducts, filled with very porous mortar, have been provided to permit ready access of water from the downstream pool to the entire intradosal surface.

Between the haunches of the arch and the walls of the canyon lean concrete filling has been placed to various heights, dependent upon the apparent stability of the natural rock walls. Above this filling and above the extrados of the arch, transverse walls 5 feet in thickness and spaced generally 20 feet center to center, have been constructed to the elevation of stream bed, these walls, as well as the filling, being for the purpose of bracing the side walls of the canyon, as a preventive of possible sliding on planes of cleavage.

In order that it may be possible to determine, at any time, the upward water pressure at various points at the base of the foundation structure, 35 4-inch galvanized and dipped pipes have been placed in the structure, leading from the points at which the uplift pressure is to be measured a few feet upward, then horizontally to four centralized points where they continue vertically upward through the structure to observation platforms above high water below the dam. The lower end of each pipe terminates in a box filled with gravel and resting on the natural material of the foundation. The pressure will be measured by determining the elevation of water in the riser pipes, or by means of a pressure gauge, if the elevation of hydraulic grade at the point where the pressure is to be measured be higher than the top of the riser pipe.

THE CUT-OFF WALL

When the fault in the stream bed was discovered, it was realized that it would be necessary to carry the cut-off wall at the fault to a great depth. The depth to which it would be necessary to excavate in other parts of the stream bed, in order to reach a satisfactory cut-off, was not known. Excavation of the cut-off trench was begun in open cut, and was carried by this method to a depth of from 26 to 33 feet below the original rock surface, corresponding to depths of from 69 to 76 feet below stream bed. The greater part of the trench required timbering. When the above depths had been reached, maintaining the open cut had become so difficult that a change of method was necessary, and it was decided to continue the excavation through shafts. The trench was filled with concrete, in which were constructed ten shafts through which the excavation and placing of concrete has been continued. The walls of the shafts have been reinforced throughout the zone of inferior rock, and well into the solid rock on either side. Stop-water key-ways have been constructed between the sections of the wall and in the interior walls of the shafts. When the excavation and grouting has been completed the shafts will be filled with concrete.

Numerous grout pipes have been inserted in the shaft walls, where the rock is broken or seamy. When, at any part of the cut-off trench, final depth is reached, grout holes, staggered in two rows 5 feet apart, spaced not exceeding 10 feet apart in each row, and extending to a depth of 25 feet, are drilled and grouted. It is proposed, also, to drill and grout thoroughly the rock easterly from the fault zone, and along the line of the cut-off wall, extending for a distance of not less than 50 feet horizontally from the end of the wall.

The length of wall constructed through shafts was, at the beginning, about 150 feet. Excavation and concrete for the full length of the wall have been carried to a depth of 197 feet below stream bed, at which depth the length of wall is 80 feet. A part of the wall has been carried to a depth of 213 feet below stream bed. It is intended to carry the wall at the fault, and as far on either side as may be found necessary to secure a key in suitable rock, to a depth of 300 feet below stream bed, with which depth the percolation factor will be 5.

No great difficulties have been experienced in the construction of the cut-off wall. The greater part of the excavation has been performed without blasting. Since the construction by means of shafts

has been in progress, the amount of shoring and bracing needed has not been large. The amount of water to be pumped has rarely exceeded two second feet and now is only about one second foot.

GENERAL

The construction of Rodríguez Dam was begun by General Abelardo L. Rodríguez, then Governor of the Northern District of Baja California, and now President of Mexico. The Ambursen Dam Company, contractor for the design and construction, began work in April, 1928. Fair progress was made during the administrations of General Rodríguez and his successor, General Tapia, which lasted about 2½ years. Since then the work has suffered many interruptions. It was suspended from March 13, to April 30, 1929, on account of the last revolution in Mexico. It was again suspended in November 1930, and was not resumed until December 1931. Again, it was suspended on September 8, 1932 and while it technically was resumed a few days later, active operations have not yet begun.

Funds for the work are furnished by the territorial government of Baja California, which at no time, except for the first few months, has been able to furnish as large amounts as were necessary for the most economical construction. The general financial depression of the past few years has further reduced the Territory's ability to supply funds. The estimated total cost of the dam is $4,250,000 and the estimated cost of completion $2,000,000.

The work at the dam, until recently, has been under the general supervision of Señor José L. Favela, General Agent of Agriculture and Development for the National Government in the Northern Territory of Baja California, representing the Governor of the Territory and also the National Commission of Irrigation, which has supervision of all irrigation development in Mexico. Señor Francisco Gómez-Pérez, until recently Resident Engineer, has succeeded Señor Favela and now is in general charge as representative of the Territorial Government. The writer is Consulting Engineer to the National Commission of Irrigation. Mr. A. J. Wiley (deceased) and Mr. F. A. Noetzli, Consulting Engineers, members of the American Society of Civil Engineers, were consultants on the important features of design and construction.

(Presented before the California Section meeting, October 27, 1932.)

GERMICIDAL EFFECTIVENESS OF CHLORINE, BROMINE AND IODINE

By T. D. Beckwith and J. R. Moser

(Department of Bacteriology, University of California, Berkeley, Calif.)

In this project, the facts desired concern the comparative effectiveness of the three halogens chlorine, bromine and iodine as germicides in water. Included in the series also has been a mixture of bromine, 90 parts, plus chlorine, 10 parts. The chlorine used in these experiments was derived from sodium hypochlorite manufactured by the Great Western Electro-Chemical Company of Pittsburg, California, while the bromine and the bromine plus chlorine mixture were the products of the California Chemical Corporation of Newark, in the same state. The iodine utilized was *Baker's Analyzed* in quality.

The bacterial flora of water are derived in very large part from soil and therefore soil suspensions made by shaking garden soil in tap water were passed through cotton in a funnel to remove gross particles. The soil suspension was prepared by adding ten grams of soil to one litre of the water. For the test suspensions used in these experiments, 200 cc. of this turbid water were added to 800 cc. of tap water. All suspensions were prepared fresh at time of use. The first portion of the problem has dealt with reduction of the numbers of bacteria derived from soil when suspended in water.

Under conditions of general usage of the halogens, chlorine or iodine, the end desired in practice is control of contamination in water. No discussion of the effectiveness of chlorine will be added here for many volumes of work dealing with it have been contributed in the aggregate. Its value is too well recognized to require comment. In these trials chlorine serves rather as a well recognized standard for purposes of comparison. Iodine has its use in military and camp sanitation, but regarding bromine little knowledge has been accumulated.

The second portion of this work, therefore, has included a series of experiments designed to offer knowledge of the disinfecting value of these elements against the colon bacillus, since this is the particular

organism which one seeks to eradicate in sanitary practice either in a supply potable for human consumption or in a swimming pool. For this purpose known B. coli was added to tap water. The strain was one which had recently been isolated from contaminated water and which was carried by daily transfers in beef extract nutrient broth. We have prepared water for these tests by addition of one cc. of a twenty-four hour broth culture to one litre of tap water. The resulting counts before treatment have been very high, much greater than may be expected to be encountered under natural conditions. On the other hand, reduction from such a level becomes much more evident following treatment and efficiencies can be computed with greater exactitude.

The water used has been that taken from a house tap served by the East Bay Municipal Utility District at Berkeley. We decided not to utilize distilled water since a certain degree of plasmolysis of added organisms would be certain to appear and thus confusion in final counts would ensue. The suspending medium should be of more nearly equal tonicity to the protoplasm of the added bacteria. This water was not sterilized by heat before addition either of B. coli or of soil bacteria.

Each of these halogens has been applied in concentrations read as parts per million. For this purpose, comparisons have been made against orthotolidin color standards. The chlorine standards were furnished through the courtesy of the Great Western Electro-Chemical Company, while the bromine orthotolidin standards were placed at our disposal by the California Chemical Corporation. This method of computation, however, was not available for iodine and therefore a one per cent solution of iodine in ethyl alcohol was prepared most carefully. Known amounts of this were then added to the water at time of test.

We have used the following procedure when carrying through a test run to determine possible killing power of one of these elements. Just preceding the period of treatment, the bacterial suspension whether of soil organisms or of B. coli was passed through a series of dilutions which were plated out according to the usual method with nutrient beef agar. From such preparation subsequently the initial count per cc. was obtainable. In tabulations to follow this count is termed the control. When the known concentration of the halogen now was added, samplings were removed following expiration of 5, 10, 30 and 60 minutes after application. These portions then were

TABLE 1

Soil bacteria in tap water—killing effectiveness of chlorine

P.P.M. CHLORINE	CONTROL	AFTER MINUTES 5	10	30	60	FINAL EFFICIENCY, PERCENT
1/10	2,100	600	540	517	360	82.9
1/4	2,100	524	420	360	300	85.7
1/4	48,000	420	380	328	312	99.3
1/2	48,000	278	252	250	250	99.5
1/2	3,050	1,300	700	500	358	88.2
1/2	27,500	840	720	350	300	98.8
1	27,500	240	210	250	240	99.1
1	3,050	442	412	310	208	93.2
1½	3,050	420	428	214	180	94.2
1½	27,500	228	194	152	150	99.8
2	27,500	184	128	130	104	99.9
2	3,050	166	181	182	160	94.8

TABLE 2

Soil bacteria in tap water—killing effectiveness of bromine

P.P.M. BROMINE	CONTROL	AFTER MINUTES 5	10	30	60	FINAL EFFICIENCY, PERCENT
1/10	2,100	720	300	258	240	88.6
1/4	2,100	520	240	200	180	91.4
1/4	3,000	280	174	168	138	95.5
1/4	48,000	436	370	367	320	98.3
1/2	48,000	294	298	276	258	98.5
1/2	3,000	216	194	198	180	94.7
1/2	2,800	1,100	1,000	600	340	88.0
1/2	20,000	3,100	2,400	2,200	2,000	90.0
1/2	3,300	420	395	355	285	91.3
1	3,300	334	350	284	238	92.8
1	20,000	1,950	1,500	1,300	1,200	94.0
1	2,800	244	224	224	225	91.9
1	3,000	228	152	152	130	95.6
1½	3,000	164	124	23	10	99.4
1½	2,800	270	254	202	208	92.6
1½	20,000	1,800	1,700	1,000	900	95.5
1½	3,300	312	270	270	210	93.6
2	3,300	234	222	200	184	97.4
2	20,000	1,800	1,000	1,000	800	96.0
2	2,800	247	216	230	164	94.1

diluted and plated out. All plates concerning the soil suspensions were incubated for two days, but preparations dealing with the colon bacillus were treated thus for only 24 hours before counting. Incubation was at 37°C. All experiments were made at room temperature, approximating 20°C.

TABLE 3

Soil bacteria in tap water—killing effectiveness of iodine

P.P.M. IODINE	CONTROL	AFTER MINUTES				FINAL EFFICIENCY, PERCENT
		5	10	30	60	
$\frac{1}{10}$	1,400	720	540	480	495	64.6
$\frac{1}{4}$	1,400	600	500	488	360	74.3
$\frac{1}{2}$	17,000	1,800	1,600	1,500	1,200	92.9
1	17,000	1,500	1,300	900	600	96.6
$1\frac{1}{2}$	17,000	1,850	1,900	1,100	1,000	94.1
2	17,000	750	700	600	500	97.1

TABLE 4

Soil bacteria in tap water—efficiencies and parts per million

HALOGENS	$\frac{1}{10}$	$\frac{1}{4}$	$\frac{1}{2}$	1	$1\frac{1}{2}$	2
Chlorine	82.9	85.7	88.2	93.2	94.2	94.8
		99.3	98.8	99.1	99.8	99.9
			99.5			
Bromine	88.6	91.4	91.3	92.8	93.6	97.4
		95.5	90.0	94.0	95.5	96.0
		98.3	88.0	91.9	92.6	94.1
			94.7	95.6	99.4	
			98.5			
Iodine	64.6	74.3	92.9	96.6	94.1	97.1

Tables 1, 2, and 3 give results obtained with each of the three elements under examination when placed in contact with organisms from soil at concentrations of germicide designated.

As a résumé to bring these results together in toto for more ready review, table 4 is presented. This shows the final efficiencies of the varying parts per million of each of the elements used when brought into contact with soil organisms suspended in tap water.

Our results of experiments, in which each of these elements together with the mixture of bromine and chlorine was applied to suspensions of B. coli in tap water, are shown in tables 5, 6, 7 and 8.

TABLE 5

B. coli in tap water—killing effectiveness of chlorine

P.P.M.	CONTROL	AFTER MINUTES				FINAL EFFICIENCY, PERCENT
		5	10	30	60	
1/10	280,000	270,000	280,000	275,000	296,000	00.0
1/10	180,000	171,000	175,000	168,000	170,000	5.5
1/4	280,000	220,000	240,000	231,000	200,000	28.6
1/4	180,000	185,000	160,000	147,000	156,000	13.3
1/2	280,000	180,000	200,000	200,000	160,000	43.0
1/2	180,000	171,000	163,000	149,000	118,000	34.4
1	280,000	200,000	170,000	110,000	116,000	60.0
1	180,000	135,000	143,000	128,000	97,000	46.1
1½	280,000	150,000	124,000	80,000	13,000	96.0
1½	180,000	56,000	58,000	14,000	6,800	96.3
1½	790,000	480,000	180,000	37,000		95.3
1½	410,000	2,400	2,300	1,500		99.6
2	790,000	6,400	6,000	5,600		99.3

TABLE 6

B. coli in tap water—killing effectiveness of bromine

P.P.M.	CONTROL	AFTER MINUTES				FINAL EFFICIENCY, PERCENT
		5	10	30	60	
1/10	1,080,000	1,100,000	1,050,000	1,020,000	1,013,000	6.2
1/4	1,080,000	660,000	256,000	193,000	184,000	83.0
1/4	1,320,000	540,000	62,000	35,000	14,500	99.7
1/4	1,398,000	48,000	36,000	2,100	2,200	99.9
1/2	1,398,000	1,500	250	165	150	100.0–
1/2	1,320,000	8,500	2,100	1,500	1,100	99.9
1/2	1,080,000	22,000	18,000	3,300	3,250	99.7
1	1,398,000	286	10	7	9	100.0–

In manner following that of table 4 a summary of the final efficiencies of these last four tables is now inserted as table 9. This includes results of the tests upon the colon bacillus only.

The outcome of these two series of tests presents certain points of interest. A large portion of the soil flora is made up of species which

produce spores. These are ordinarily resistant to adverse conditions. Most of the vegetative bacteria of soil on the other hand are Gram positive in tinctorial reaction. Bacterial organisms giving this

TABLE 7

B. coli in tap water—killing effectiveness of bromine, 90 per cent + chlorine, 10 per cent

P.P.M.	CONTROL	AFTER MINUTES				FINAL EFFICIENCY, PERCENT
		5	10	30	60	
¼	660,000	168,000	100,000	108,000	102,000	84.4
¼	300,000	248,000	180,000	168,000	156,000	44.9
½	300,000	6,200	1,900	1,400	900	99.8
½	660,000	8,600	2,100	350	300	99.9
1	660,000	5,400	840	200	138	99.9
1	300,000	458	70	80	42	99.9+
1½	660,000	490	460	320	228	99.9
1½	1,440,000	6,600	5,400	3,500	1,500	99.7

TABLE 8

B. coli in tap water—killing effectiveness of iodine

P.P.M.	CONTROL	AFTER MINUTES				FINAL EFFICIENCY, PERCENT
		5	10	30	60	
$\frac{1}{10}$	534,000	530,000	527,000	525,000	515,000	3.6
¼	524,000	372,000	275,000	200,000	150,000	71.9
¼	1,500,000	1,260,000	1,140,000	900,000	272,000	81.8
¼	1,920,000	720,000	600,000	540,000	400,000	78.5
½	1,920,000	9,800	8,600	4,200	3,600	99.9
½	1,500,000	7,200	4,000	3,100	1,600	99.9
1	1,500,000	4,000	3,600	3,900	3,800	99.6
1	1,920,000	300	157	122	114	100.0–
1½	1,920,000	10	6	5	8	100.0–
1½	1,500,000	1,000	550	400	250	100.0–
2	1,500,000	100	100	0	0	100.0
2	1,920,000	24	4	5	5	100.0–

positive reaction are usually more susceptible than those which are Gram negative. Tables 1, 2 and 3 which concern soil forms indicate marked activity even with greatest dilution of the germicidal agent. It is evident thus that large numbers of spores must have been killed and therefore that these elements under the conditions of these tests

were potent in this respect. However, B. coli is a Gram negative organism and higher concentrations of the disinfectant are essential to eradicate it. This effect becomes evident when one views the various tables dealing with this organism.

A brief consideration of the possibilities of building up a residuum of these materials in water was given by us. Our series of tests concerning this question as applied to bromine particularly are of importance and interest. The residual bromine found to remain in certain of the suspensions used in the preceding experiments may be

TABLE 9

B. coli in tap water—efficiencies and parts per million

HALOGENS	$\frac{1}{10}$	$\frac{1}{4}$	$\frac{1}{2}$	1	$1\frac{1}{2}$	2
Chlorine	00.0	28.6	43.0	60.0	95.3	99.3
	5.5	13.3	34.4	46.1	99.6	
					96.0	
					96.3	
Bromine	6.2	99.7	99.9	100.0−		
		99.9	100.0−			
		83.0	99.7			
Bromine 90 per cent + chlorine 10 per cent		84.4	99.9+	99.9+	99.9	
		44.9	99.8	99.9+	99.7	
Iodine	3.6	81.8	99.8	99.6	100.0−	100.0−
		78.5	99.9	100.0−	100.0−	100.0−
		71.9				

stated to be the following. Two parts of bromine after a lapse of 60 minutes in the tap water showed a residual of 0.3 p.p.m. upon one occasion. Applications of one part per million of bromine were tested at the end of one hour following two different experiments. Of these, one showed 0.2 p.p.m. residual, while the other was proved to contain 0.1 p.p.m. bromine. However, no residual was evident at the close of 60 minutes when 0.5 p.p.m. or less had been applied. These residual readings, however, are rather less than the usual figures with chlorine. We found no iodine remaining as such when tests were conducted with orthotolidin, but this reagent is by no means ideal for use with iodine and thus the outcome with this particular

halogen should not be taken as final. The fact of value developed, however, is that residual bromine may be built up in water.

SUMMARY

The effectiveness of the three halogen elements, chlorine, bromine and iodine, has been tested comparatively in tap water taken from the supply of the East Bay Municipal Utility District in Berkeley. Experiments have been conducted upon killing effects both upon large inocula of bacteria derived from soil suspensions and likewise upon relatively enormous contents of B. coli added from cultures.

The activity of each of the elements here considered upon that portion of the water bacterial flora derived from soil is approximately equal. Applications of as little as 0.1 p.p.m. of each were followed by marked lethal efficiencies. Numerous spore producers thus must have been eradicated.

When the comparative germicidal values of chlorine, bromine and iodine upon B. coli are considered, each is found to reveal high potency, but of these three, bromine appears to be most effective since 0.25 p.p.m. of this elements gave higher percentage efficiency kill than did either of the other two under the conditions of these experiments.

The germicidal efficiency of this series of elements, however, does not appear to follow the principle of an effectiveness increasing according to molecular weight inasmuch as iodine at 126 is somewhat less active than bromine at 80.

Residual bromine may be shown to be present after sixty minutes from time of application of initial concentrations of one part per million in the water used by us. A similar condition thus may be expected to develop within the water of a swimming pool.

AN ANALYSIS OF METERED REVENUE

By P. J. Dishner

(High Point, N. C.)

The City of High Point, N. C. is located in the Piedmont section of the above state. It is predominantly an industrial center with two leading industries: furniture and textiles. Furniture has played an important part in the development of the city, so much that it is known as the "Grand Rapids of the South." In later years the textile industry has made great strides and is represented by cotton and silk mills and hoisery mills, knitting and dyeing hosiery of all materials. The population according to the U. S. Census of 1930 is 36,745.

The water system is municipally owned and is operated by the Utilities Department. There is an average total of 6,514 consumers supplied by 5,695 services. All services are metered except 11 domestic consumers on flat rate. The difference between the number of services and the number of consumers results from cases where two or more users receive water through the same service and meter. These multiple services supply domestic users.

In 1931, when the writer was in charge of the Utilities Department, he felt the need for a more complete analysis of revenue accruing from the sale of water. One purpose was to secure better accounting. Another was to obtain a greater knowledge of the characteristics of the various consumers, which would aid in determining the cause of variations in revenue and the requirements of different types of users. This would result in a closer watch on revenue and greater accuracy in planning extensions and improvements. A third reason was to obtain information and data that would be useful in planning rate changes.

The present rate structure is of the block type and the cubic foot system of measurement is used. The City operates the lighting system and both water and light meters are read monthly. The water meter readings are in units of 100 cubic feet as the readers disregard the two lesser digits. The readers work in pairs: one reader, carrying the book and making all entries, reads the light meters and his

helper reads the water meters. Total amounts used are computed as the readings are set down to eliminate as many errors as possible.

The daily analysis sheet is divided into three major divisions: Domestic Water; Commercial Water; and Industrial Water. These divisions are subdivided into consumption groups. For example, the Domestic Water division is subdivided into the following consumption groups: 0–300; 400–1300; 1400–2600; 2700–4000; 4100–5300; 5400–6600; 6700–13300; 13400–26600; 26700-plus; in units of cubic feet. The other major divisions are similarly subdivided, with two additional groups. In each consumption group are spaces sufficient to make all entries resulting from a maximum day's reading. It was realized that considerable space was being wasted, but the form was prepared so that no reader could make a mistake.

METER ANALYSIS

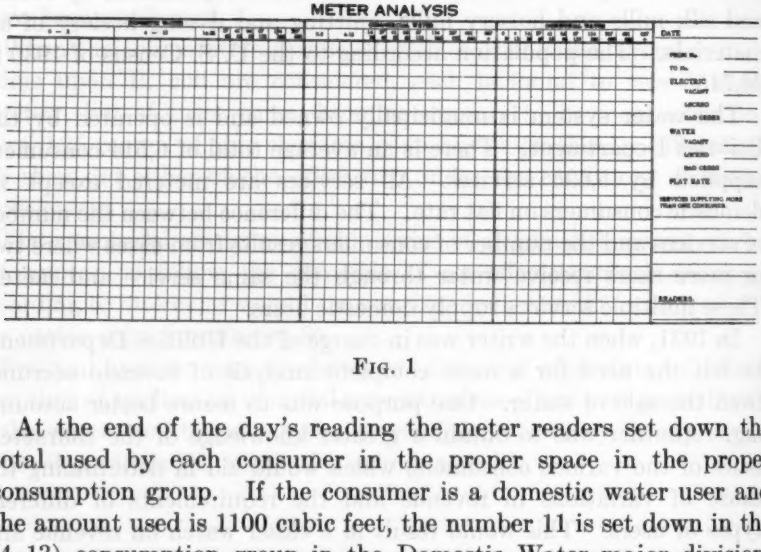


FIG. 1

At the end of the day's reading the meter readers set down the total used by each consumer in the proper space in the proper consumption group. If the consumer is a domestic water user and the amount used is 1100 cubic feet, the number 11 is set down in the (4–13) consumption group in the Domestic Water major division. If the consumer operates a restaurant and has used 5800 cubic feet, the number 58 is set down in the (54–66) consumption group in the Commercial Water major division. If the consumer has a furniture factory and has used 45,000 cubic feet, the number 450 is set down in the (401–666) consumption group in the Industrial Water major division. The meter readers check the accuracy of this work by the number of entries made against the number of services accounted for. Other entries pertaining to inactive services, locked meters,

TABLE 1

Analysis of water consumption data

CONSUMPTION GROUPS, GALLONS	AVERAGE NUMBER SERVICES PER MONTH	AVERAGE CONSUMPTION PER SERVICE PER MONTH, GALLONS	AVERAGE TOTAL CONSUMPTION PER MONTH, GALLONS
1. Domestic water			
0– 2,250	2,310	1,666	3,849,245
3,000– 9,750	2,550	4,531	11,554,220
10,500– 19,500	177	13,155	2,328,399
20,250– 30,000	44	25,684	1,130,099
30,750– 39,750	19	34,188	649,582
40,500– 49,500	9	42,003	378,029
50,250– 99,750	11	65,712	722,823
100,500–199,500	4	146,826	587,305
200,250–plus	1	500,527	500,527
Totals..............	5,129	3,655	21,700,238
2. Commercial water			
0– 2,250	144	1,442	207,654
3,000– 9,750	168	5,201	873,757
10,500– 19,500	63	14,084	887,285
20,250– 30,000	25	23,694	592,354
30,750– 39,750	12	35,461	425,532
40,500– 49,500	8	41,978	335,825
50,250– 99,750	16	52,712	843,397
100,500–199,500	9	138,637	1,247,735
200,250–300,000	2	262,418	525,837
300,750–499,500	3	376,782	1,130,347
500,250–plus	5	778,564	3,892,821
Totals..............	455	24,093	10,962,544
3. Industrial water			
0– 2,250	8	1,496	11,969
3,000– 9,750	13	5,236	68,075
10,500– 19,750	8	14,198	113,583
20,500– 30,000	5	25,422	127,111
30,750– 39,750	4	36,016	144,067
40,500– 49,500	5	47,665	238,325
50,250–999,750	16	68,671	1,098,742
100,500–199,500	18	143,583	2,584,491
200,500–300,000	7	232,599	1,628,196
300,750–499,500	11	389,795	4,287,745
500,250–plus	5	826,829	4,134,149
Totals..............	100	144,364	14,436,453

bad order meters, flat rates, and services supplying more than one consumer are made at the same time. This work requires from 15 to 30 minutes of the readers' time at the end of the day's work.

The daily analysis sheet (See fig. 1) is turned over to the utility clerk for compilation. The utility clerk totals the number of consumers and the amounts used in each classification and consumption group. The results are checked against the totalizer on the billing machine. At the end of the meter reading period the daily totals are used to prepare the monthly recapitulation.

TABLE 2

Water used by average domestic consumer

MONTH 1931–1932	AVERAGE CONSUMPTION PER CONSUMER, GALLONS	
	Per month	Per day
December	3,546	114
January	3,524	113
February	3,161	109
March	2,957	95
April	3,333	111
May	3,340	108
June	3,919	133
July	4,252	137
August	4,408	142
September	4,657	155
October	3,608	116
November	3,311	110

The monthly recapitulation shows the total number of consumers, the average amount used per consumer, and the total quantity used, in each classification and each consumption group.

An analysis of the twelve month period from December 1–1931 to December 1–1932 is set forth in table 1. The data have been computed in gallons instead of cubic feet. The extremely large consumer in the Domestic Water group is a private company supplying a large subdivision without the corporate limits.

The average amounts used by the average domestic consumer per individual month are shown in table 2. The number of consumers is obtained by adding the number of domestic services and the number of additional consumers supplied through multiple services.

The writer feels that the results obtained were well worth the

effort. This method requires data covering a period of twelve consecutive months to insure reliable statistics. Best results are obtained by making such an analysis continuous.

He believes that it enables the Superintendent to keep in closer contact with his market—the consumer. Variations in the quantity consumed by domestic consumers are due to seasonal and weather changes and in commercial and industrial users are due to business conditions. Abnormal variations can be promptly recognized.

Characteristics of consumers vary in different communities. Such an analysis, by determining true requirements, enable extensions and improvements to be planned more exactly than by using old "rule of thumb" methods.

No rate changes were contemplated, but any change would tend toward simplification, such as elimination of several blocks. The writer believes that by the detailed analysis future revenue can be predicted with sufficient accuracy.

This was the writer's first attempt at such an analysis. He was especially anxious to avoid the confusion and errors that occur when the analysis is made at the end of the meter reading period. He believes that a maximum of information was obtained at a minimum of expense.

IODINE IN THE WATER SUPPLY OF LEXINGTON, KENTUCKY

By J. S. McHargue and D. W. Young

(*Contribution from the Department of Chemistry of the Kentucky Agricultural Experiment Station, Lexington, Ky.*)

The iodine content of municipal water supplies is a problem of increasing importance from the standpoint of nutrition and public health, in certain parts of the United States. The drinking water and the foods produced in certain parts of this country are low or deficient in iodine, and as a consequence endemic goiter is frequently more prevalent among the people living in those regions than elsewhere.

McClendon,[1] at the University of Minnesota, has determined the iodine content of water from a number of streams and lakes which are the source of drinking water for a considerable number of towns and cities in this country. The results are shown in table 1.

The Department of Chemistry of the Kentucky Agricultural Experiment Station has made determinations of the iodine content of the city water supply of Lexington, Kentucky, for the period of September 1, 1931, to September 1, 1932. During normal rainfall, Lexington obtains its supply of water from four artificial lakes whose maximum capacity is approximately 1,750,000,000 gallons. The lakes are fed by surface runoff, springs and branches which are more or less permanent with normal rainfall. During the severe drouth of 1930, it was necessary to construct a pipe-line to the Kentucky River and water was brought from this stream until normal rainfall in the latter part of 1931 made further pumping unnecessary. Pumping from the Kentucky River had ceased some time previous to the collection of the first sample of water for iodine determination in this investigation. Samples were collected on the first day of each month from a faucet in the chemical laboratory at the Experiment Station building at Limestone Street and Washington Avenue.

The results of the monthly determinations of iodine in the city water and the average for the year are given in table 2.

[1] McClendon, J. F. The distribution of iodine with special reference to goiter. Physiological Reviews, 7: 2, 1927, pages 189–258.

The maximum result for iodine was found in the sample of water collected on November 1, and the minimum in the sample collected on April 1. The average of 14 determinations is 14.04 p.p.b. iodine.

Previous investigators have reported considerable fluctuation in the iodine content in water supplies where determinations were made

TABLE 1

Iodine content of certain waters

	IODINE, PARTS PER BILLION
Rivers	
Mississippi River at Minneapolis, Minn.	0.88
Mississippi River at St. Paul, Minn.	0.83
Mississippi River at St. Louis, Mo.	3.52
Mississippi River at New Orleans, La.	7.70
Missouri River at Kansas City, Mo.	1.69
South Platte River at Denver, Colo.	0.77
Scioto River at Columbus, O.	0.21
Cumberland River at Nashville, Tenn.	0.22
Susquehanna River at Harrisburg, Pa.	0.23
James River at Richmond, Va.	0.60
Potomac River at Washington, D. C.	0.72
Oconee River at Atlanta, Ga.	3.20
Average of 12 samples of river water	1.71
Lakes	
Lake Superior at Duluth, Minn.	0.01
Lake Superior at Marquette, Mich.	0.02
Lake Michigan at Milwaukee, Wis.	0.015
Lake Michigan at Winnetka, Ill.	0.10
Lake Michigan at Chicago, Ill.	0.12
Lake Erie at Cleveland, O.	0.86
Lake Ontario at Toronto, Canada	1.45
Average for 7 samples of lake water	0.37

at regular intervals over a period of time. The results for iodine in the water supply for Lexington during the course of a year also show considerable fluctuation.

On April 29, 1932, a five-gallon sample of water was collected from the Ohio River, at Louisville, Ky., at a point about 100 yards south

of the east end of the new municipal bridge and about 100 feet from the bank. A determination of iodine in this water gave 4.7 parts per billion.

On the same date, a five-gallon sample of water was collected from the Kentucky River a short distance west of the bridge at Frankfort, Ky., and 7.2 parts per billion of iodine was found in this water.

The average result for iodine in the city water for Lexington, is considerably more than the results for this element in any of the river or lake waters reported by McClendon. This may be accounted for

TABLE 2

Amounts of iodine in Lexington Water

DATE OF SAMPLE	IODINE, PARTS PER BILLION
September 1, 1931	12.2
October 1, 1931	14.3
November 1, 1931	22.0
December 1, 1931	21.3
January 1, 1932	13.3
February 1, 1932	12.8
March 1, 1932	14.0
April 1, 1932	9.0
May 1, 1932	15.8
June 1, 1932	11.6
July 1, 1932	10.8
August 1, 1932	12.9
August 13, 1932	12.6
August 15, 1932 (untreated)	14.0
Average of 14 samples	14.04

(Amount of sample used—20 liters.)

by the fact that the watershed for the reservoirs at Lexington is underlain with limestone strata and the soils derived from the limestone contain approximately 400 times as much iodine as the untreated water from the reservoirs. From these data it may be inferred that the foods produced and the water supply of this locality contain an ample quantity of iodine; accordingly a very small percentage of goiter patients is to be observed among the inhabitants of this part of the state.

(The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.)

A COMPARISON OF THREE METHODS OF DETERMINING THE COLON-AEROGENES GROUP*

By August G. Nolte

Chief Chemical Engineer, Chain of Rocks Plant, St. Louis, Mo.

and Warren A. Kramer

Senior Chemical Engineer, Chain of Rocks Plant, St. Louis, Mo.

The inadequacy of the present standard method of bacterial analysis of water has long been recognized by water bacteriologists and sanitarians. The main disadvantages of the present lactose broth fermentation tests as described in Standard Methods[1] are:

(a) The number of tubes showing gas formation in 48 hours bears no significant relationship to the Bact. coli content of the water. An additional 48 hours test must be performed before the coli index can be established.

(b) Gas formation in the lactose broth is brought about by anaerobes and symbiotic combinations of other organisms,[2] which obscures and may nullify the test for Bact. coli.

(c) A needless amount of time and effort is consumed by transferring those gas positive tubes which do not contain Bact. coli. Hinman[3] found that 80 percent of the positive tests in lactose broth were not due to the colon organism, while Raab[4] showed that 90 percent of the gas presumptive tubes proved negative on further examination. In our laboratories a survey of the routine tests shows that in the twelve months ending August 31, 1931, 5858 tubes inoculated with 10 ml. portions of unfinished and finished water showed gas formation in 48 hours. Of those only 1337 or 23 per cent were established positive for Bact. coli.

* Study carried on as routine procedure in the Chain of Rocks Laboratory of the St. Louis Water Division by Robert E. Kelly, Senior Medical Student, St. Louis University, St. Louis, Missouri.

[1] American Public Health Association, Standard Methods of Water Analysis, Sixth Edition (1925).

[2] Sears, H. J., and Putnam, J. J., J. Infectious Diseases, 32, 270 (1926).

[3] Hinman, J. J., Am. J. Public Health, 15, 614 (1925).

[4] Raab, F., J. Am. Water Works Association, 10, 1051 (1923).

Work has been done in numerous laboratories on the problem of substituting a procedure which will eliminate these false presumptive tests and give an index of the sanitary conditions of the water in as early as 48 hours. Two channels of investigation have appeared exceedingly promising. One is the cyanide citrate agar of Noble.[5] This is a solid pour plate medium based upon the work of Ayers and Rupp,[6] Koser[7] and Muller.[8] By this medium, in the opinion of Noble, not only a direct colon-aerogenes index of the water, but also the separate counts of these two groups of organisms can be obtained in as short a time as forty-two hours.

A second type of medium, greatly different in principle is the brom cresol purple, methylene blue medium of Dominick and Lauter.[9] This is a lactose broth to which a combination of dyes have been added to inhibit the metabolism of bacteria not of the colon-aerogenes group and still allow lactose utilization with formation of acid and gas by the colon organisms.

Published reports of the use of these two types of media are meager and those found in the water works literature deal, in the main, with relatively highly polluted waters affording a high colon index, and furnish little proof as to the advisability of adopting either method in the routine analysis of plant samples and samples of water collected from consumers' taps. Accordingly direct comparison series between the cyanide citrate agar, the Dominick-Lauter medium, and the Standard Methods lactose broth tubes, were run simultaneously on the plant and tap samples of the Chain of Rocks Station during the months of July, August and September, 1931, with the thought in mind of establishing the quickest and most accurate method for use in routine procedure in our laboratory.

COMPARATIVE RESULTS WITH CYANIDE CITRATE AGAR AND STANDARD METHODS

A pour plate method for the determination of the colon-aerogenes index of water has been developed by Noble.[5] This is a synthetic medium containing the constituents of the earlier solid medium of

[5] Noble, R. E., J. Am. Water Works Association, 19, 182 (1928).

[6] Ayers, S. H., and Rupp, P., J. Bact., 3, 433 (1918).

[7] Koser, S. A., J. Bact., 8, 493 (1923).

[8] Muller, L., Societe de Biologie, Compt. rend. et Memoires, Tome III, 984, 1251 (1922).

[9] Dominick, J., and Lauter, C., J. Am. Water Works Association, 21, 1067 (1929).

Ayers and Rupp, to which Noble has added ferric citrate and potassium ferrocyanide. The theoretical principles involved have been discussed by Noble. The advantages of any method of direct plating of samples over previous lactose broth enrichment are too obvious for explanation. The disadvantages are none the less apparent. Noble has obtained satisfactory correlation between direct plating and lactose broth fermentation tests in dealing with sewage and with waters from swimming pools, but has published no data on results with waters of high sanitary quality. Parallel inoculations into cyanide citrate agar plates and Standard Methods lactose broth tubes of 769 samples of water, varying from raw river water to water furnished the consumer, have been made to determine the value of this method when applied to waters differing in Bact. coli content.

Procedure

Two direct pour plates were inoculated with 10 ml. portions of water each. At the same time the samples were tested for the colon-aerogenes content as outlined in Standard Methods. Daily tests were made on raw water, unfinished water, and finished water taken from fourteen points in the distribution system. The medium used in the early part of this investigation was identical with that first proposed by Noble.[5] In later stages of the experiment the revised cyanide citrate agar was used.[10]

Results of investigation

The results of parallel inoculations of the 769 samples of unfinished and finished water of the Chain of Rocks Station into "Standard Methods" lactose broth tubes and cyanide citrate agar do not establish the feasibility of this pour plate method for routine analysis of all types of water. The appearance of the colon-aerogenes group, while exceedingly typical in pure culture inoculations, is not at all characteristic when samples of water are plated without previous enrichment. In the waters of higher coli content a somewhat characteristic type of colony appeared, but even here the same color and form were taken by organisms definitely proved later not to be Bact. coli. Likewise several different types of colony, varying from reddish pink to deep reddish black were found to be Bact. coli. The presence or absence of Bact. coli colonies could not be predicated on the appear-

[10] Tonney, F. O., and Noble, R. E., J. Am. Water Works Association, 23, 1202 (1931).

ance alone, because of this lack of a typical color and form. Therefore, all reddish colonies were suspected of being coli organisms and transferred to lactose broth. They were termed Bact. coli positive, only if gas formation occurred within 24 hours after the transfer. This method precluded the possibility of overlooking any colon colonies and gave a satisfactory index of the number of Bact. coli which grew on this medium. A comparison of results obtained by Standard Methods Broth and Cyanide Citrate Agar is shown in table 1.

COMPARATIVE RESULTS WITH METHYLENE BLUE, BROM CRESOL PURPLE MEDIUM AND STANDARD METHODS

The use of dyes to inhibit the growth of non-coli organisms has been the basis of much study. The greatest amount of work has been done on gentian violet and brilliant green, using the latter singly

TABLE 1

Comparison of results with Standard Methods broth and cyanide citrate agar

PROCEDURE	RIVER WATER		UNFINISHED WATER		FINISHED WATER	
	Number of samples	Percent positive	Number of samples	Percent positive	Number of samples	Percent positive
Standard Methods	38	100.0	129	10.1	602	1.3
Cyanide citrate agar	38	86.8	129	4.7	602	0.2

and in combination with bile.[11] Salle[12] gives a full account of these studies. The results obtained from the use of these dyes have not furnished conclusive evidence of the efficacy of these methods. In the concentrations used to eliminate the anaerobic gas-formers, there seems to be too great an inhibitory effect upon the Bact. coli group. Dominick and Lauter[9] have recently published reports relative to the use of brom cresol purple, methylene blue and erythrosine, which, when added to the lactose broth, eliminates a large percentage of false presumptive tests, and possesses no toxic effect on organisms of the Bact. coli group. In an effort to establish the value of this method when applied to all types of water, 697 samples of finished and unfinished water of the Chain of Rocks Station were examined for their colon-aerogenes content by the Standard and the Dominick-

[11] Koser, S. A., J. Infectious Diseases, 35, 14 (1924).

[12] Salle, A. J., J. Am. Water Works Association, 21, 71 (1929).

Lauter Methods. As the Standard Methods and Dominick-Lauter media so nearly correlated in all samples of river water examined during the preliminary work the comparisons of the two media with river water samples were not included in the series.

Procedure

Seventeen samples including settled, applied, filtered, and chlorinated finished water of the Chain of Rocks Station were examined daily by the Standard Method and the Dominick-Lauter procedure. The amount of the individual samples tubed in these experiments was governed by the routine practice of the plant laboratory. Accordingly, five 10 ml. and two 1 ml. tubes were used on the unfinished waters. Of the fourteen finished water samples four were inoculated into five 10 ml. and two 1 ml. tubes, while one 10 ml. and two 1 ml. tubes sufficed for the remainder. The explanation of these variations in the quantity of finished water tested lies in the fact, that those samples receiving five 10 ml. tubes constitute the four main points on the distribution system, and the other samples merely furnish additional checks on the water after it passes these points. The tubes were incubated at 37°C., observations being made at the end of 24 and 48 hours, and transfers made of any tubes showing 5 percent or more gas formation.

Endo's medium[1] was used as the confirming agar, and typical colonies were again transferred to lactose and confirmed by gram and spore stains. All Dominick-Lauter 10 ml. tubes containing unfinished water were transferred to Endo plates at the end of forty-eight hours, whether gas formation had occurred or not. Any suspicious colonies were tested according to Standard Methods to determine the presence of Bact. coli. In this manner we endeavored to ascertain if the dye exerted any bacteriostatic effect on the lactolytic powers of Bact. coli. No colon colonies appeared on Endo plates streaked from Dominick-Lauter tubes which had previously showed no gas formation. Growths occurred on these plates but none were found to be Bact. coli. The methylene blue, brom cresol purple medium was prepared according to the original publication of Dominick and Lauter,[9] slightly revised by them in a later communication.

Results of investigation

A much larger number of gas positive tubes is obtained by the Standard Method than by the brom cresol purple, methylene blue

medium. However, on further examination only 4.6 percent of these tubes showing gas by Standard Methods were confirmed, while 76.5 percent of the Dominick-Lauter gas tubes show the presence of Bact. coli. The coli index obtained from the parallel series is slightly greater by the Dominick-Lauter medium than by the Standard Method lactose broth. These data are shown in table 2.

The Dominick-Lauter medium is effective on all types of water from the most polluted to those of high sanitary quality. Our results indicate that it is most effective on waters low in Bact. coli content. In the series dealing with the tap samples 100 percent

TABLE 2

Comparison of results with standard lactose broth and Dominick-Lauter medium

PROCEDURE	UNFINISHED WATER			FINISHED WATER		
	Number of tubes planted	Percent showing gas	Percent confirmed	Number of tubes planted	Percent showing gas	Percent confirmed
Standard Methods	615	45	6	1,230	22	3
Dominick-Lauter	615	7	72	1,222	0.7	100

TABLE 3

Comparison of results by three methods of detecting colon-aerogenes group

PROCEDURE	UNFINISHED WATER		FINISHED WATER	
	Number of samples	Percent positive	Number of samples	Percent positive
Standard Methods	123	8.9	574	0.9
Dominick-Lauter	123	11.4	573	1.1
Cyanide citrate agar	129	4.7	602	0.2

confirmation of the presumptive tubes was obtained. This is in striking contrast to the Standard Method sowings in which only 3 percent of the lactose broth tubes showing gas were confirmed.

There appears to be little, if any, inhibitory effect upon Bact. coli by the concentration of dyes used in the Dominick-Lauter medium. Only 4 samples of the 697 examined were proved positive by Standard Methods and not by the Dominick-Lauter procedure, while eight samples were positive by the latter medium only. There were four more samples proved positive by the Dominick-Lauter medium than by the Standard Methods. Any possible error resulting from the use

of this medium would, therefore, be on the side of safety. It is our opinion that this greater number of positives results from the inhibition of non-coli organisms, which in the standard lactose broth tubes may prevent the growth and metabolism of Bact. coli.

GENERAL CONCLUSIONS

A total of 769 samples of water have been examined simultaneously using Standard Methods lactose broth, Noble's cyanide citrate agar and Dominick-Lauter's methylene blue brom cresol purple broth as the culture media. The following conclusions may be drawn from the results obtained (tables 1, 2 and 3) by the use of these three media on highly polluted, unfinished (plant samples) and finished waters (tap samples).

1. A relatively close correlation exists between the results obtained by the three media on the examination of polluted (river) water.

2. In its present state the direct determination of organisms of the colon-aerogenes group in waters of high sanitary quality by the cyanide citrate agar is not practical for use in our laboratory.

3. With the unfinished water the Dominick-Lauter broth proved superior to the Standard Methods broth, in that a much smaller percentage of tubes gave a presumptive test with a much larger percentage of confirmations, without sacrificing the reliability of the final results. The cyanide citrate agar did not prove to be as reliable as either of the other media.

4. With the finished water the Dominick-Lauter broth proved far superior to the Standard Methods broth, in that a very much smaller percentage of tubes gave a presumptive test with a very much larger percentage of confirmations, with greater reliability of the final results. The cyanide citrate agar proved very much inferior to the other media.

5. The Dominick-Lauter method of determining the presence of organisms of the colon-aerogenes group in samples of water examined as routine procedure in our laboratory is the best method of the three for our use because it is the simplest, quickest and most reliable. However, it lacks acceptance as standard procedure and therefore we are hesitant in adopting it as such. It is hoped that the Committee on Standard Methods will investigate this medium with a view to adopting it if found worthy.

AMMONIATION PRACTICE IN THE EAST

By William J. Orchard

(*General Sales Manager, Wallace & Tiernan Co. Inc., Newark, N. J.*)

"Ammoniation Practice in the East" differs not in the least from ammoniation practice in the West. Certain geographical peculiarities might prompt the installation of the process for one of its many virtues in preference to another, but this is probably as true locally as it is nationally.

Just recently our company questioned some two hundred or more users of the ammonia-chlorine process on the following points:

Purpose for which ammonia is being used, and its success in serving this purpose.

Ratio of ammonia-chlorine rates of feed.

Effectiveness of chloramine (as formed by ammonia-chlorine process) as a preventative of chloro-phenol taste; as chlorinous odor and taste eliminator; as an algaecide; advantages of the persistent residual characteristics.

Observations and comment on possible lag in sterilization (chloramine as compared to chlorine alone).

General impression of the process and its future in water treatment practice.

Tabulating the replies, we find that 10 percent of the installations were made primarily for the prevention of chloro-phenol tastes and odors. All of these reported complete success. Twenty-five percent of the installations were made for the prevention of purely chlorinous tastes and odors—all of these were successful—and 25 percent were made for the prevention of other tastes and odors which seemed to some extent to be aggravated by the use of chlorine. With one exception these were entirely satisfactory. Fifteen percent of the installations were made primarily for the benefits secured through the persistent residual characteristics of chloramines and an additional 15 percent of the users reported this benefit as being of great value to them.

[1] Journal, April, 1932, page 494.

Of the 25 percent installing the process either primarily or secondarily for algae control, 80 percent reported complete satisfaction,—20 percent reporting partial control.

Twenty-five percent reported some lag in the velocity of sterilization. Ten percent reported no observance of this lag, while 65 percent made no comment on this point.

When it is remembered that the use of the ammonia-chlorine process received its recent great impetus from publicity accorded its successes in preventing chloro-phenol tastes, it comes somewhat as a surprise to find that only 10 percent of the installations are actually being employed for this purpose.

Although 30 percent of the installations report a noticeable benefit from the persistent residual characteristic of the chloramines, it is to be expected that the ability to prevent aftergrowths in distribution systems; to guard against recontamination in reservoirs and mains and to deliver a tasteless, odorless water containing a chlorine residual right at the consumer's faucet is an added public health protection that of itself justifies the installation of the ammonia-chlorine process in most cases.

Satisfactory algae control has been obtained in some rather unusual circumstances. Perhaps an outstanding example is that reported by Bauermann[1] in his article "Ammoniation in the Newark Water Supply." Here, in a reservoir containing a theoretical ten days supply, using a residual of 0.4 p.p.m. at the inlet (with the use of the ammonia-chlorine process), it was possible to maintain the reservoir entirely free from algae and the consequent tastes and odors that algae had caused in previous years and at the same time deliver a water consistently free of aftergrowths. Residuals of 0.14 p.p.m. were reported at the outlet of this reservoir, although it is believed that short circuiting reduced the theoretical ten day retention to something approaching five days.

Time alone prevents my citing more than a few of the replies received to this questionnaire and I have endeavored to pick instances where some element of the unusual may be found.

Mr. L. E. Smith, Superintendent, Water Department, Canton Water Works, Canton, New York reports:

"Have always been troubled with chlorine or chlorophenol tastes. About five months ago we began using the ammonia-chlorine process. It is introduced in the water main at a point near the inlet of the reservoir.

"Before adopting this process we were continually receiving complaints of

tastes and quality of the water. We have never received a complaint since changing.

"We are treating with chlorine at the rate of 0.6 p.p.m. and ammonia at the rate of 0.23 p.p.m. and carry a residual of from 0.15 to 0.25 p.p.m. This residual is maintained at all points in the distribution system. We have obtained this same residual ten days after the water was treated.

"We are more than pleased with this method of treating the water."

Mr. H. W. Schumpert, Superintendent Water Works, Electric Lighting and Sewer Department, Newberry, S. C. reports, in part:

"This treatment was installed to combat objectionable tastes and odors from algals and from decaying leaves and excreta. The ratio of ammonia to chlorine in extended dry weather was 1 to 3 but this ratio and high dosage was occasioned by the treatment being applied to the incoming raw water storage of three days capacity. . . . . The ammonia-chlorine has been wonderful, in fact we never have a complaint from tastes and odors now and too, we find it a great aid in algae control."

At the City of Monroe, N. C., ammonia was installed to combat a decided woody taste and to control algae. Ammonia is added to the water at the bottom of the mixing chamber and allowed to mix for 5 or 6 minutes before chlorine is applied. Combined ammonia and chlorine has a 12 minute contact before it enters the settling basins which have a normal retention period of five hours. It was found that in order to carry a 0.1 p.p.m. residual in the distribution system, it was necessary to apply an average dosage of 0.36 p.p.m. ammonia and 1 p.p.m. chlorine or a ratio of 1 to 3. The treatment was successful to the extent that it kept the basins and filters free from algae and noticeable microscopic life and slightly increased the filter runs.

Reporting on the installation at Hibbing, Minnesota, Mr. Ole Forsberg, Bacteriologist, says:

"The application of chloramines to our water supply is made with two definite purposes: to control aftergrowths in the distribution system and to eliminate the chlorinous tastes which are present when chlorine alone is used. During the past two years the results from the ammonia-chlorine treatment have been very gratifying and it has accomplished all that we hoped it would. The ratio of 1 ammonia to 3 chlorine is found to give the most satisfactory results. Other ratios were tried but we finally decided on the 1 to 3 as being the most economical.

"In our opinion the chloramine treatment is especially valuable in sterilizing water having a higher chlorine absorption power and with such water, a retention period of at least two hours is required."

Mr. J. J. Shank, Boro Chemist, Waynesboro, Pennsylvania, discussing the installation at this point, says in part:

"During the drought of the past two years in this locality at which time we were faced with a greatly diminished water supply and the resulting concentration of the contamination which is normally present, chlorine did not seem effective in controlling the supply. . . . . Maintaining a feed which operated the chlorination system at capacity, we were unable to obtain a chlorine residual in the distribution system because of the organic content of the water treated and other conflicting conditions. . . . . Examination indicated that the water supply entering the city was satisfactory, but that the water supply in certain parts of the city was badly contaminated at points beyond the junction of the balancing reservoir with the mains. . . . . Under date of August 7, 1931, it was recommended by the Boro Chemist that an ammoniation system be installed and used in conjunction with the chlorine treatment. Accordingly, the installation of an ammoniator equipment was approved by the Boro Council and installed and put into operation on August 19, 1931. An immediate improvement was noted. Within 24 hours it was possible to detect chloramine in the water supply at various places in the water. . . . . At the end of 24 hours chloramine residual averaged 0.4 p.p.m. At this time the dosage was 11 lbs. chlorine to 3 lbs. of ammonia. On August 23rd the feed was reduced to 8 lbs. chlorine and 2.8 lbs. ammonia per 24 hours and a residual chlorine content of 0.3 to 0.4 readily maintained at all points in the distribution system. . . . . At present with a flow of 2 m.g.d. we are using 6 lbs. chlorine and 2 lbs. ammonia per 24 hours and maintaining a chloramine residual of 0.3 to 0.4 constantly. Economically, the present treatment results in an actual saving to the Boro since the cost of the combined treatment for 24 hours is less than the cost of chlorine used prior to August 19, 1931.

"Since the installation of the ammoniating equipment we have not obtained a single positive confirmatory test for B. coli in the water samples examined. Water samples are collected daily and constant laboratory control of the entire system is practiced. . . . I am very much pleased with the results obtained and the City officials are entirely satisfied that their decision has improved conditions which were assuming an alarming aspect."

Speaking of the installation at the Water and Light Plant City of Duluth, E. W. Kelley, Manager, says:

"As a result of our experience with chloramine process we expect that this process will continue to be a permanent feature of our practice. We have been very much pleased with the results obtained as to the degree of sterilization, as to the prevention of aftergrowths, as an eliminator of tastes and odors arising from algae and arising from the use of chlorine itself."

Mr. Carl A. Hechmer, Department Engineer, Washington Suburban Sanitary District, Md., in discussing the process, says:

" . . . From our experience ammoniation is effective in preventing the formation of chlorophenol tastes, chlorinous odors and tastes and other tastes

and odor producing compounds which are formed by the application of chlorine but the water must be originally free of tastes before chlorination. Ammonia is not sufficient in the prevention of marshy, river, woody and muddy tastes which usually accompany high turbidities in the raw water and are present in the water before chlorination. . . . It is also the writer's opinion that the chloramine treatment controls bacterial growths in the distribution system, increasing bactericidal efficiency by permitting the maintenance of high residual chlorine content in the tap water without danger of being noticed by the consumer and therefore has a definite place in water purification. Its use should be considered in all taste and odor prevention studies."

Indirect benefits were also reported in a number of cases. As an example, reporting on the installation at Huntingdon, Pa., J. G. Dell, says:

"During the summer of 1931 we had much trouble resulting from algae. Our filter runs were very much shortened and we got a repulsive odor and taste in our effluent. To eliminate this we tried copper sulphate in as large a dose as we dared use. The condition still remained."

After going on to discuss other methods of treatment which were tried, Mr. Dell continues:

"Finally we installed a W & T Ammoniator and introduced ammonia-chlorine treatment ahead of our low lift pumps. In a short time the odor disappeared. The filter runs were so lengthened that now we get as much as fifty hours sometimes before the loss of head is 8 ft. We practice post-chlorination at very light dosages.

"At first we used as high as 18 lbs. of chlorine and 8 lbs. of ammonia per mg. Now we have reduced it to about one-third the amount."

Differences of opinion have been expressed regarding the lag in the velocity of sterilization. With very few exceptions observers report a very distinct lag and in the work of the W & T Research Laboratories this lag was early noticed and commented upon. Most discussions of the treatment have warned the operator against the installation of the ammonia-chlorine process where the time interval between treatment and the first consumer would not permit of sufficient contact to overcome this lag. We now find that with the exception of such installations as are used for the prevention of chlorophenol tastes, it is quite feasible—in fact, one might say desirable—to treat with chlorine first, perhaps at rates considerably higher than normal, and subsequently "detaste" and stabilize the chlorine residual with the addition of ammonia. In this way adequate sterilization having been effected with the introduction of the heavier chlorine

dosages, the addition of the ammonia creates chloramines with all of their advantages and yet does not prohibit the immediate use of the treated water. This fact is becoming more generally recognized and with it the knowledge that plants hitherto presenting what appeared to be physical obstacles to the installation of the combined ammonia-chlorine treatment may now satisfactorily install the process and secure all of its benefits.

SWIMMING POOLS

While naturally those of you who are here today are much more concerned with the benefits to be derived from the use of the ammonia-chlorine process on water supply installations, I may mention that a large number of swimming pools are now successfully employing this treatment. Here again the persistent residual characteristic has proven invaluable. Large outdoor pools with relatively slow turnover have been able to maintain residuals in all parts of the pool with very normal rates of chlorine application, where in the past with chlorine alone it has proven almost impossible to apply dosages sufficiently heavy to penetrate all sections of the pool, and yet not build up concentrations at the inlet obnoxious to the bathers. Not only this, but the tasteless, odorless, non-irritating features of this ammonia-chlorine sterilization appeal alike to the patron and the pool operator. The ammonia-chlorine process has taken a definite place in swimming pool practice, just as it has in the water works field.

(Presented before the California Section meeting, October 27, 1932.)

REPORT OF COMMITTEE NO. 8 ON CROSS CONNECTIONS*

(Approved, 1933, by the Committee on Water Works Practice)

At the Louisville convention of the American Water Works Association in May, 1925, the Fire Protection Division of the Association adopted certain resolutions regarding cross-connections between public potable water supplies and supplies from other sources. (See Appendix E.) In June, 1930, at its St. Louis meeting, the Association appointed Committee No. 8 on Cross-Connections which presented a progress report under date of April 23, 1931. No other formal action has been taken by the Association.

During the past few years, the subject of cross-connections has been much discussed at meetings of the Association and of other societies. Furthermore, numerous papers dealing with this subject have been presented and published and much available information has accumulated. Many state health departments have adopted rules either prohibiting cross-connections or regulating their installation and maintenance and other states are considering the matter. In some cases local municipal ordinances or rules cover this matter of cross-connection. The United States Public Health Service in connection with the certification of water supplies for use by inter-state carriers has recognized the importance of the problem.

In recent years, many investigations have been made by various agencies to discover and eliminate, insofar as practicable, existing cross-connections and, with the cooperation of property owners, much has been accomplished. New protective devices for use with cross-connections have been developed and are being installed where approved by state health departments.

Practically all available data on this subject together with the results of investigations for elimination or safeguarding cross-connections subsequent to 1925 have been studied by this Committee. Consequently, the conclusions of this report are based upon definite information relative to actual accomplishments in the way of protecting public water supplies from the hazards incidental to cross-

* Submitted May 2, 1932.

connections. The report which follows attempts to present all new data and evidence, but necessarily contains considerable material previously published.

REPORT

Definition. For the purposes of this report, a cross-connection may be defined as any physical connection by means of which water may flow between a public or private potable supply and a non-potable supply.

Examples of cross-connections. One of the most common cross-connections is that between a municipal water supply and a private non-potable supply, so arranged as to permit the use of either or both for industrial purposes, such as washing, cooling, quenching or processing. Ordinarily, the private supply is used and the public supply held in reserve.

Another example and one which probably has received the most attention is the connection between a public supply and a private fire protection system. Such a connection permits the public supply to maintain pressure on sprinklers and hydrants at all times while the private supply, usually from a fire pump or elevated tank comes into use only at times of fire or test. In event of fire, both supplies furnish pressure and volume simultaneously. Temporary cross-connections with polluted sources, also, are sometimes made by hose attached to fire department connections.

In addition to the types of cross-connections which are associated with industrial plants there are other cross-connections incidental to the development of municipal supplies themselves. For example, emergency intakes from polluted sources and bypasses around purification plants are distinctly hazardous cross-connections. Through such connections, polluted water may be admitted to the distribution system with serious results to public health unless prompt and adequate disinfection of such water can be put into effect.

Many other cross-connections between water pipes and wastes pipes may exist on individual premises. Water pipes may discharge into sewers for flushing purposes under conditions which will permit backflow when low water pressure is coincident with sewer surcharge or when siphonic action may occur. In some cases, private household supplies from wells or cisterns of questionable quality may be cross-connected with the public supply. Danger of local pollution of the water in household piping systems often exists as the result of im-

properly designed or installed plumbing fixtures. Other examples of cross-connections are given in Appendix A.

REASONS FOR CROSS-CONNECTIONS

Interruptions and failures of public supply. Frequently the public water service is interrupted for ordinary repairs and changes to street mains. Occasionally, major interruptions in service occur when extraordinary circumstances result in large sections of a municipality or even the whole city being supplied with water in reduced volume and at low pressure. A partial list of such major interruptions comprising 405 cases has been compiled. A few cases are given in Appendix B, illustrating failures from typical causes.

In many instances, cross-connections are made in order to permit the use of the public supply for boiler feed and for manufacturing processes. Under such conditions, interruptions in an adequate supply of water might result in serious damage to machinery, equipment and stock in process. To avoid such damage, reserve auxiliary sources of supply are frequently considered essential.

Probably the strongest reason for cross-connections is the importance of guarding against the failure of the water supply at times of fire. A failure of supply when fire occurs may well be a disaster resulting in loss of both life and property.

Cost of public supply for industrial use. Another reason for industrial cross-connections is the desire for economy in manufacturing operations. Non-potable water sufficiently satisfactory for many types of process work can often be obtained for the cost of pumping only. Consequently the purchase of potable water at a greater cost may not be justified from the standpoint of plant economies, although it is usually desirable to hold the public supply in reserve for use when a breakdown of private equipment or power occurs.

Inadequacy of public supply. A third reason for cross-connections lies in the fact that the water supply for fire sprinklers must not only be ready for service at all times but must be of adequate pressure and volume. Far too often the pressure and volume available from the public supply are distinctly moderate or entirely inadequate. On this account a direct cross-connection is frequently used in the case of large properties to permit fire pumps to obtain supplies from ponds, rivers or other practically inexhaustible sources. In the case of a serious fire, the combined capacities of both the public and private supplies might be required.

Inadequacy of private supply. A similar reason corresponding to that immediately preceding results from the frequent inadequacy of private supplies which precludes their use without reinforcement by the public system. Private supplies are subject to interruptions by drought, freezing, flood, failure of power and other causes. Some private industrial supplies are not in service Sundays, holidays and during mill shutdowns. Consequently, it may be of considerable value to a mill to have its private supply cross-connected so that the public supply may be available in time of emergency.

Many cross-connections are in use where there is no real need and have been installed simply as a matter of convenience or because it is too much trouble to eliminate them. Certain cross-connections, such as those between water pipes and sewage pipes and improper arrangements in plumbing fixtures are the result of ignorance and carelessness.

OBJECTIONS TO CROSS-CONNECTIONS

Possible contamination of public supply. Valuable data on the contamination and infection of public water supplies through cross-connections with polluted supplies are contained in the monograph of Wolman and Gorman upon "The Significance of Water-borne Typhoid Fever Outbreaks, 1920–1930." This study disclosed the fact that, as regards water-borne disease during the period in question, unprotected cross-connections as a cause rated first in the number of cases of typhoid; second in the number of outbreaks; fourth in the number of dysentery cases and fourth in the total number of typhoid and dysentery cases. An unprotected cross-connection, as referred to by Wolman and Gorman, is one which is not equipped with modern protective devices.

In Appendix C of this report will be found 26 instances where infection of public water supplies has occurred through cross-connections and 8 instances of such infection through the use of auxiliary intakes and bypasses. The cross-connections involved in these outbreaks of water-borne disease were provided with one, two or three gate valves with or without one or two check valves of the ordinary commercial type.

The above citations are ample evidence of the serious hazard to public health inherent in cross-connections and the many examples of water-borne outbreaks of typhoid and dysentery constitute powerful arguments against cross-connections. In fact, the health hazard is so important that other objections, even though they might exist, are unnecessary.

As regards the emergency use of polluted sources of supply and the bypassing of water purification devices, it is obvious that the objections to such practices are also based upon the danger to public health.

POLICIES OF PUBLIC HEALTH AUTHORITIES

Federal policy. The elimination and control of cross-connections, auxiliary intakes, and bypasses is of such importance that on January 11, 1930, the Surgeon General of the United States Public Health Service issued a circular letter to all State Health Officers outlining a policy to be followed in certifying potable water supplies used by interstate carriers for drinking and culinary purposes. In this letter, it was stated that the existence of cross-connections must be considered and that full certification should not be given unless connections to non-potable waters were either eliminated or "equipped with modern protective devices approved by the State Department of Health and installed and operated under the direct control of that department." Auxiliary intakes and bypasses were considered as in the same category as cross-connections.

State policies. A circular letter dated January 7, 1931 was sent by this Committee to all State Departments of Health asking what regulations, if any, had been adopted regarding cross-connections and requesting information about the manner and success of enforcement. Replies were received from 43 states. A summary of these replies, tabulated in Appendix D, shows that: 13 states had regulations prohibiting all cross-connections; 9 had regulations permitting protected cross-connections; and 20 were without specific regulations, but 14 of these handled the problem under a definite policy. No definite policy was indicated in the replies of four states; few cross-connections, if any, existed in two other states; and one state had regulations which prohibited cross-connections with unapproved surface water supplies, but did not specifically prohibit cross-connections with unapproved ground water supplies. Considering the definite policies of the states without regulations, the replies to the circular letter indicate that in a total of 18 states cross-connections were prohibited and in a total of 19 states protected cross-connections were permitted.

Of particular interest is the action of twelve states which adopted regulations subsequent to the resolutions of the fire-protection division of this Association, May, 1925.

The following states adopted regulations prohibiting cross-connections, on the dates indicated:

1. Kansas, June 1, 1925
2. Montana, October 7, 1926
3. Washington, 1924, revised January 28, 1927
4. Oregon, May 27, 1927
5. Kentucky, December 12, 1927
6. Missouri, April 3, 1928

The following states adopted regulations allowing protected cross-connections, on the dates indicated:

1. Connecticut, July 12, 1926
2. Maryland, July 1, 1926, amended October 7, 1926
3. New York, November, 1925, qualified July 3, 1928
4. New Jersey, September 18, 1928
5. Tennessee, 1928, officially promulgated March, 1930
6. Maine, August 19, 1930

The Connecticut Department of Health regulations prohibit cross-connections with non-potable supplies after December 31, 1926, except that installations protected by double check valves of approved design with adequate facilities for testing and which were in existence on December 31, 1926, may be temporarily continued, with the permission of the State Department of Health. Frequent inspections of the double check valves are being made by the state authorities and as yet no permission for protected cross-connection has been revoked. New cross-connections are not allowed.

The Maryland Department of Health regulations prohibit cross-connections with auxiliary supplies unless approved by the State Board of Health and state that they "shall be removed on or before October 1, 1926, unless approved by the State Board of Health." Any direct connection between a well, pure water reservoir, or a potable supply and a sanitary sewer or storm-water drain for the purposes of carrying away the overflow of the well or reservoir, is not permitted unless approved by the State Board of Health. In but one instance have cross-connections in industrial plants between the municipal supplies and the plant supplies been allowed. In this case, the quality of the public supply is safeguarded by the introduction of special type double check valves.

The Public Health Council of the New York State Department of Health amended the Sanitary Code on November 12, 1925, to take effect July 1, 1926, by prohibiting any physical connection between

potable and non-potable supplies, except that where the cross-connection was already equipped with two check valves of the special Factory Mutual Fire Insurance design or equivalent, the date of discontinuance could be extended to July 1, 1928. On June 27, 1928, the Public Health Council extended the date of discontinuance from July 1, 1928, to January 1, 1929. On July 3, 1928, the State Commissioner of Health notified local water authorities that a chlorinator, capable of effectively chlorinating an auxiliary water supply pumped intermittently, had been developed and that the installation and proper maintenance of such a chlorinator would make the auxiliary supply potable from the standpoint of public health. All bronze double check valves are also required before approval is granted for the use of protected cross-connections.

On September 18, 1928, the New Jersey State Department of Health enacted Chapter XIII of the Sanitary Code which stipulates that after April 1, 1929, no cross-connection, bypass, valve, pipeline, auxiliary intake, or other similar device, which might permit any flow of water into an approved public water supply from any unapproved supply, shall be permitted, except that where such connections existed on April 1, 1929, and were equipped with all bronze double check valves, the date of continuance might be temporarily extended. New cross-connections are not allowed.

The Tennessee State Department of Public Health is handling its cross-connection problems as outlined in Regulation 34 officially promulgated in March, 1930. This regulation states that after January 1, 1928, cross-connections between a public water supply and any other water supply shall not be permitted unless the quality of such other water supply, and the interconnection of the two supplies, are approved by the State Department of Public Health, provided, "That in certain exceptional cases in which the maintenance of a complete absence of any cross-connection between a public water supply and a non-potable auxiliary supply is not found to be reasonably possible, the existence and maintenance of a cross-connection may be permitted by the State Department of Public Health and continued regardless of the non-potable quality of the auxiliary supply, subject always to the following conditions." The principal conditions are, that the auxiliary supply shall be used only for fire fighting purposes; that double check valves of the "all bronze" type shall be installed and properly maintained; that a fire pump chlorinator shall be provided; and that the auxiliary water supply must not be so grossly polluted that it cannot be effectively chlorinated. The regulation further provides

that "No auxiliary intake for a public water supply shall be permitted unless the source and use of the auxiliary supply and the location and arrangement of the intake have been approved by the State Department of Public Health." The regulation also states that "After January 1, 1928, no bypass shall be permitted at any water purification plant of a public water supply unless such bypass is approved by the State Department of Public Health."

The Maine Public Health Council approved on August 19, 1930, rules and regulations made by the State Department of Health, which went into effect July 1, 1931. The principal features of these regulations are, briefly:

1. All cross-connections shall be eliminated and disconnected before July 1, 1931, unless protected by all-bronze double check valves installed in standard manner and adequately maintained. (See figure of double check valve installation in Appendix F.)

2. A private non-potable water supply may be used in connection with a public potable supply on condition that there be installed an open tank, reservoir, or standpipe supplied from the potable source through a pipe, the open end of which shall be above the highest point to which non-potable water may rise.

3. No new cross-connection shall be installed after January 1, 1931, until a permit to install such cross-connection has been secured from the State Department of Health.

In some states, funds and personnel are sufficient to permit the State Department of Health engineers to study conditions on the ground and to make detailed suggestions of the changes necessary to comply with requirements. In these states subsequent visits are often made to inspect the completed changes, and if protective devices have been installed, to examine them occasionally. Complete enforcement and correction of unsatisfactory conditions can be obtained when ample funds and personnel are available. In most states, the local health and water authorities carry out much of the detail of enforcement of the state requirements. This plan has generally worked well, if the cooperation of the property owner is obtained, if a reasonable amount of assistance is given him by the local authority, and if the requirements are not such as to work an undue hardship on the property owner. A few states are so handicapped by lack of funds and personnel that cross-connection activities are confined mostly to examination and approval of plans of new construction and changes. Little is being accomplished in those states in eliminating or safeguarding old cross-connections except in

those cities where supplies have been provisionally certified for common carrier use by the United States Public Health Service.

The information secured from the circular letter of this Committee indicates that the intensive campaigns of several states have been very successful. The regulations of at least seven states, including several of the large manufacturing states, have been so well enforced that few known unprotected cross-connections exist. As additional connections of this type are discovered from time to time, the regulations are promptly enforced. Many other states are continuously locating cross-connections so that the possibilities of water-borne outbreaks of disease from this cause are being steadily reduced.

Since 1925, many hundred cross-connections have been eliminated and several hundred have been equipped with all bronze fire service double check valves. Where these protective devices have been required, property owners have generally made the installations within the time limits allowed. Sixty-eight or more fire pump chlorinators have been installed in New York State in addition to all-bronze double check valves.

Municipal policies. Inasmuch as the State Departments of Health are charged with the responsibility of the public health and the approval of public potable water supplies, it is logical that the municipalities should accept the requirements of the State Department as their requirements. Most municipalities have followed this practice. A few cities have established more reigid requirements. Where state departments have advisory powers only or for other reasons have adopted no regulations, a small number of cities have promulgated regulations which either prohibit all cross-connections or require the elimination of most of them and the installation and proper maintenance of modern protective devices at the few which are permitted to remain.

Conference of State Sanitary Engineers. In October, 1929, the Conference of State Sanitary Engineers adopted a report of its Committee on cross-connections. Although this report was not concerned with cross-connections with sewers, around water-purification plants, and through auxiliary intakes, it stated that none of these should be permitted. Cross-connections with swimming pools and toilet and other fixtures were, however, considered, a phase of the problem not covered in previous reports to the Conference.

The conclusions of the Committee are quoted below:

"Your committee wishes to reiterate the recommendation of the 1926 cross-connection committee of the Conference of State Sanitary Engineers that all

cross-connections should be abolished between safe drinking water supplies and other water supplies of a quality unapproved for human consumption by the state or other health authorities having jurisdiction.

"The committee desires to call attention to the fact that in a number of states no action has yet been taken to definitely eliminate such connections or even to partially protect them by the use of double check valves of the latest improved type, subject to adequate and periodic testing and overhauling. It is not within the province of this committee to set forth what definite policy is best suited to the needs of any particular state in elimination of cross connections. There undoubtedly are in some states cross connections which it is not feasible to completely eliminate under existing conditions without dangerous fire hazard. This may mean that temporary control may have to be resorted to by the installation of double check valves but your committee feels that such measures should be considered only as temporary and ultimately should be eliminated in favor of complete separation.

"From the evidence available, the all-bronze check valves developed by the Associated Factory Mutual Fire Insurance Companies are decidedly superior to any form of protective device yet developed. The relative measure of success obtained with such valves rests largely on the degree of supervision afforded them.

"The automatic start-and-stop chlorinator is another type of safeguard and is being used to a limited extent to supplement the protection afforded by the double check valves. In some ways, it might be compared to a third check valve, but its advocates have looked at it from a different viewpoint—as another type of protection. Your committee feels that this chlorinator is too new a development to warrant any further comments.

"The committee believes that progress could be made in the development of new plumbing fixtures by the designation of this committee or some other committee to represent the Conference in taking up with the plumbing industry the matter of elimination of production of toilet and other fixtures which admit the possibility of pollution of water supply systems."

The resolutions submitted by the committee and adopted by the Conference in October, 1929 are given in Appendix E.

RESOLUTIONS OF WATER WORKS ASSOCIATIONS

American Water Works Association. The fire protection division of the American Water Works Association adopted and the Association approved resolutions at the annual convention in May, 1925, to the effect that no cross-connection between a potable public water supply and another supply should be permitted except where the second supply is a potable public supply or where it is a potable supply regularly examined as to its quality. The resolutions are given in full in Appendix E.

New England Water Works Association. A cross-connection committee of the New England Water Works Association presented a

final report December 12, 1928. The Association members later voted favorably on the report by letter ballot and the resolutions recommended by the committee were adopted by the Association on February 13, 1929. The report deals largely with cross-connections for fire service and was the most complete report available on this phase of the subject. The resolutions, which are given in full in Appendix E, place the responsibility of determining what waters are "bacterially unsafe" on the state health authorities.

The conclusions of the committee are quoted below:

"The Committee recognizes that the only absolute safeguard for the purity of water supplies is complete separation of potable and non-potable supplies. Many cases exist in industrial as well as fire lines where cross-connections can be entirely eliminated without extensive changes or undue hazard to life and property. Such connections should be immediately abolished. In other instances the abolition of such cross-connections presents a very serious problem from the standpoint of possible loss of life and property by fire. Each case should be carefully studied on its own merits to determine the best procedure, all interests being considered. So far as possible, steps should be taken in each community to provide public water supplies of sufficient adequacy and reliability, even to providing a secondary potable supply if necessary, so as to eliminate the necessity for cross-connections of any kind.

"The Committee feels that pending the establishment of adequate and reliable supplies for protection of life and property from fire, experience to date indicates that double check-valves of the latest improved type, properly installed and adequately supervised, furnish the best protection of any single device now known. It is essential, however, that such installations be regularly and frequently inspected and tested. Installations of this type are relatively recent and whether or not such installations give sufficient protection, is a question that is still open for decision on the basis of further experience.

"The Committee is of the opinion that the recently developed chlorinator for auxiliary supplies offers another valuable means of defence against bacteriological contamination of public water supplies through cross connections. However, the Committee believes that more experience must be gained with this device, before it can be unqualifiedly recommended. Properly operated and maintained, the device provides a method for making polluted auxiliary supplies, bacteriologically safe, even though such supplies might continue to be non-potable.

"Your Committee does not approve the use of cross-connections between safe and unsafe supplies, and wherever auxiliary supplies are made safe by treatment there should be provided the additional safeguard of proper and properly installed and inspected double check-valves. Furthermore, these valves should be used between drinking water supplies and those that while unpotable,—like pure sea water,—do not require treatment to make them safe.

"The Committee strongly urges that states adopt suitable laws and regulations covering the control of cross-connections and that in each community an investigation of the existing cross connections be made immediately and a pro-

gram for the elimination or control thereof be inaugurated by the local authorities. The Committee also urges that, where possible, the inspections be made through the coöperative efforts of state and municipal authorities on the one hand and owners and insurance companies on the other. Inspections of all installations or protective devices should be made at least quarterly by an official responsible for the quality of the public water supply and such devices should be overhauled yearly.

"While this report is largely concerned with cross-connections for fire service, there are many other cross-connections like those with sewers, around water purification plants and through auxiliary intakes. None of these should be permitted."

Maine Water Utilities Association. A cross-connection committee report of the Maine Water Utilities Association was approved by the Association, April 23, 1930. The report took the form of "Suggested Rules and Regulations Governing Cross Connections" which were presented to the Public Health Council of the State of Maine with the recommendation that they be adopted and placed in force at the earliest possible date.

As a result of this action, a committee representing the State Department of Health, the Maine Water Utilities Association, and the Associated Industries of Maine, worked out regulations which were approved by the Maine Public Health Council, August 19, 1930, and went into effect July 1, 1931. The principal features of the regulations which were actually adopted, and which are being successfully enforced, are indicated in this report under the heading "State Policies."

Although the suggested rules and regulations of the Maine Association were not adopted by the state authorities, it is desirable to have them readily available for reference, consequently they will be found in Appendix E.

METHODS FOR ELIMINATING CROSS-CONNECTIONS

Cooperation with property owners. One of the first steps in a program to eliminate cross-connections is a thorough and searching survey to locate as many of them as possible. Every property known or suspected of being provided with a secondary source of water supply should be visited; the cross-connections, if any, actually located; their dangers pointed out and the owner's cooperation requested in their elimination. If field study by the state or local authorities can be given to the problem of water supply which confronts every large user, and if definite methods for elimination of cross-connection can be suggested which will still permit reasonable flexi-

bility of service, then the property owner can be readily persuaded to make the desired changes. Direct contact with the property owner will accomplish far more than correspondence.

Investigation will show that large numbers of cross-connections are unnecessary and are retained only as a matter of convenience or because of the indifference of the property owner. Such cross-connections should be disconnected at once. In many cases, a moderate number of changes will be necessary requiring some field study as indicated above, and in other cases very extensive changes must be made to effect elimination. A liberal policy in allowing time to complete the elimination of the more complicated cross-connections will also assist in obtaining the cooperation of the property owner.

In connection with requirement for physical separation of public and private supplies, it should be pointed out that any arrangement whereby a cross-connection is discontinued by removing a flanged elbow on a pump discharge or a filling piece, is dangerous if there is a possibility that the unprotected cross-connection would be re-established in an emergency. Such emergency action would create a public health danger in violation of the regulations which required the physical disconnection. The spirit of the regulations should be complied with, as well as the physical requirements.

Open tanks. One method of eliminating cross-connections especially adapted to situations where industrial water has to be pumped, is by means of an open tank with the fill pipe from a potable supply located above the overflow. The service pump can then take suction from the non-potable source or from the open tank filled with potable water, without maintaining a cross-connection. Another arrangement is for the service pump to draw water from a cistern or reservoir which can be filled independently without cross-connection from both the potable and non-potable sources.

Another method of eliminating cross-connections, where pumping is employed only in part, is by means of an elevated tank or standpipe. The impure water can be pumped either directly to the private distribution piping or to the tank, and the potable water may be supplied to the elevated tank or standpipe through a separate pipe terminating in an open end above the highest level which the impure water can reach. A ball float valve can be provided on the potable water supply pipe if it is desired to fill the tank or standpipe automatically.

Swinging joints. A simple and inexpensive method of eliminating

industrial cross-connections is by means of a flexible pipe connection normally attached to the piping system of one of the water supplies. In case of emergency, this flexible pipe can be disconnected and swung over for connection to a pipe of the other supply. The swinging joint can be readily made up in any pipe size desired. The inlet end is connected by a union to either the normal or emergency water supply system and the discharge end is connected by a standard ball joint to the distribution piping of the mill.

By this method of elimination, either one of the water supplies may be used but not both at the same time. Because of this feature, the swinging joint is not suitable for the elimination of fire service cross-connections. The arrangement is especially adapted to situations where the two supplies are under pressure and do not require pumping.

Adequate development of public water supplies. It is generally realized that inadequate public waterworks are hindering the elimination of some cross-connections. If a private non-potable water is to be abandoned and entire dependence placed upon the public potable supply, interruptions to the public service must not occur or at least be reduced to a minimum. The public service should be as reliable and flexible as possible. Strengthening the distribution system by new mains, additional gates, standpipes or elevated tanks; improvement and enlargement of purification and collection systems; all of these should be studied for the purpose of making possible the elimination of cross-connections. It is sometimes feasible to provide service from both high and low pressure public water systems and thus bring about the abandonment of a non-potable private supply. Occasionally, connections from two or more streets with proper gates between will give the reliability desired and permit the elimination of a cross-connection.

Improvement of existing private reservoirs, cisterns and wells. Private reservoirs and cisterns for the storage of potable water should be constructed with tight masonry walls and bottoms so that ground water cannot enter; walls should be extended at least 6 inches above grade so as to exclude surface water; roofs should be preferably of concrete; and filling water should be taken from the public potable supply only. Many existing reservoirs and cisterns, which are now unsatisfactory, can be made to conform to the above general requirements by structural improvements and by the elimination of waste water returns, roof drains, and other sources of unsatisfactory water. Reservoirs and

cisterns which have contained water of doubtful quality should be thoroughly cleaned and disinfected. Fresh hypochlorite of lime, high test hypochlorite or chlorine gas may be used as a disinfectant.

Inspections of private wells which furnish presumably potable water and which are cross-connected with public supplies will often show that the physical conditions at many of the wells and the sanitary conditions of the surroundings are unsatisfactory. Many property owners can use the public water at all times and abandon their wells without hardship. The water from other wells in this category can be considered safe for use if all sanitary defects are corrected to the satisfaction of the health and water authorities. A system of periodic bacteriological examinations of samples from auxiliary well water supplies and periodic inspections of the wells should be inaugurated in municipalities where cross-connections with private wells exist.

EXPERIENCE WITH PROTECTIVE DEVICES

The public health hazard of direct cross-connection between public water supplies and polluted private supplies has been so well and so long recognized on the one hand and the demand for adequate and uninterrupted fire and industrial supplies so insistent on the other hand that various devices on such connections have been used to prevent contamination of the public supplies and at the same time retain assurance of sufficient volume and pressures for industrial uses.

For cross-connections 4-inch in diameter and smaller, commercial type check valves have been used exclusively. Although this type of check valve will prevent the escape of excess pressure, it is not an adequate protective device from the standpoint of public health. Furthermore, single check valves are of little more value as a protective device than no check.

Double check valves. At some extensive industrial properties where the hazards to life and property are large, it is sometimes impossible at any reasonable expense to store potable water in sufficient quantity to provide for a heavy fire demand. Although iron body double check valves were in use for many years prior thereto, it was in 1926 that the all bronze double check valve installation was developed to meet large instantaneous fire demands by permitting a simultaneous use of the public supply and private non-potable supplies of large or inexhaustible capacity. In this type of valve, the body and working parts are entirely of bronze and carefully made to jig. The clapper is provided with a domeshaped rubber facing, insuring tightness on a

wide seat ring. The valves are installed in pits, for frequent inspection, and pressure gages and drains are provided so that tests for tightness can be made. See Appendix F (description of devices) for figure and description of all bronze double check valves.

During a period of eighteen years prior to 1926, well over 1,000 double check valve installations were made in the United States and Canada using a special type iron body check valve with working parts entirely of bronze. On December 1, 1931, there were about 680 sets of all bronze double check valves installed in the United States.

The field experience of several organizations with double check valves is given in Appendix F "Results of Inspections and Tests of the Protective Devices." Included in this Appendix are the results of tests made in 1930 on 357 installations of all bronze and 811 of the special type iron body check valves by the Inspection Department, Associated Factory Mutual Fire Insurance Companies; tests made from January 1, 1927 to December 31, 1930 on 49 installations of all-bronze and 113 of the special type iron body, check valves by the Connecticut State Department of Health, and tests made from 1910 to 1930, inclusive, on 82 double check valve installations by the Water Department, New Bedford, Mass. Only one of the installations at New Bedford was the all-bronze type. The results at New Bedford are of interest because the average period of service of the double check valves was 15.6 years and the maximum period was 20.0 years. In none of the above tests was a set of all bronze check valves found to be in a leaky condition (2324 tests), although in a very few cases double check valves of the iron body type were found leaky.

Appendix F also contains an account of extensive tests of double check valves at Naumkeag Mills, Salem, Mass., by the Massachusetts State Department of Health, November and December, 1916. The report of these tests states that "passage of salt harbor water into the mains on the city side of the check valves was prevented."

Automatic chlorinators. As a further safeguard for cross-connections, an automatic start and stop chlorinator was developed in 1928. Sixty-eight or more installations have been made in New York State at non-potable auxiliary fire supplies. This machine is an adaptation of the vacuum type solution feed chlorinator commonly used in public water works. The essential differences are that it is *automatic* rather than *manually* controlled and the dosage is fixed at 20 pounds per million gallons. The chlorinator is kept in operative condition by an auxiliary injector continually drawing a small quantity of chlorine

gas through the machine to waste. The excess dosage will permit sterilization of the maximum delivery of the pump and the fixed dosage without possibility of adjustment is of no concern, as the water is not to be used for human consumption. A description of the automatic start and stop chlorinator is given in Appendix F.

The New York State authorities realizing that excellent maintenance of the chlorinator would be necessary for satisfactory operation established the following requirements which apply to this feature:

"1. The water supply must not be so grossly polluted that it cannot be effectively chlorinated.

"7. Reports of the results of daily ortho-tolidin tests of the chlorine solution wasted and the amount of chlorine wasted or used per day must be submitted at least monthly to the municipal water-supply authorities.

"8. Chlorinators on all auxiliary industrial or fire supplies must be inspected regularly and at frequent intervals by local water-supply authorities.

"11. Any approval by the municipal and water-supply authorities or this Department will be given only on condition that the chlorination apparatus is satisfactorily installed, operated, and maintained at all times."

Appendix F contains a full statement dated January, 1931 by Mr. Earl Devendorf, Associate Director, Division of Sanitation, regarding the experience of the New York State Department of Health with the automatic start and stop chlorinator. Briefly, Mr. Devendorf advised that the chlorinators had been in service approximately two years and had "operated with equal satisfaction to apparatus installed and maintained to treat public water supplies. . . . The apparatus, if properly maintained and operated, has been found capable of satisfactorily chlorinating auxiliary water supplies in intermittent operation. . . . ." "In conclusion, the operation of the fire pump chlorinators on industrial fire supplies in this state, has in my opinion, been all that could be expected. While there were a number of adjustments necessary, as there would be in any new piece of equipment, the apparatus has, in general, been given satisfactory supervision and where such supervision and maintenance have been proper, the equipment has functioned effectively."

It is evident from the above statement that while the chlorinator has been relatively satisfactory, it is subject to the same limitations as regards the human element as occurs with practically all purification devices. Although of value, the chlorinator cannot be considered as equivalent to complete severance of cross-connections.

Maintenance and regular tests. For the proper performance of protective devices, it is necessary that they be properly installed and that frequent and reliable inspections and tests be made by responsible authorities. An annual internal examination and cleaning is an essential part of good maintenance of double check valves. Several state departments of health make proper installation and adequate maintenance of double check valves a requisite for permission to retain protected cross-connections.

In New York State the all-bronze check valves "must be inspected and tested at least monthly and taken apart, thoroughly cleaned and any worn parts replaced at least yearly." In Maine, monthly inspections of all-bronze check valves by the property owner or jointly by him and the public water department with reports to the State Department of Health, are required and in addition a semi-annual inspection by a representative of the Department of Health is required. Wisconsin requires monthly, and New Hampshire semi-annual, inspections by the water departments, with reports to the State Board of Health. In Connecticut the inspections, about four a year, are made by a representative of the State Department of Health. Regulations for the maintenance of double check valves were drafted by the Maryland State Board of Health in October, 1928. Tests for tightness are required monthly, and internal inspections every six months. An extra rubber facing is required to be kept available.

The New Bedford, Mass., water department has averaged 2.65 tests per year over a period of 20 years and are now testing each installation for tightness every three months. An annual internal inspection and cleaning is also being made.

The frequency of, and the responsibility for, inspections in the states and city mentioned illustrate representative methods of maintenance and inspection of double check valves. Definite requirements for inspections, especially an internal cleaning, are lacking in some states which permit protected cross-connections.

EMERGENCY INTAKES AND BYPASSES

The monograph entitled "The Significance of Waterborne Typhoid Fever Outbreaks 1920–1930" previously referred to, indicates that auxiliary intakes to polluted sources caused 2.7 percent of the dysentery cases and slightly under 1 percent of the typhoid cases in the United States during that period. The paper also shows that con-

sidering the total number of persons in the United States affected with typhoid and dysentery in this period, auxiliary intakes to polluted sources ranked sixth as a cause. The number of outbreaks in the same period was four. Appendix C lists eight epidemics which occurred over a period of years caused by auxiliary intakes and bypasses. It is also probable that many other similar outbreaks have occurred of which no readily available record has been made.

The reasons for the existence of these emergency intakes and bypasses are: inadequate source of potable water, insufficient capacity of treatment plants, or insufficient filtered water storage. Sometimes the arrangement is such that no physical connection normally exists, but when it becomes necessary to use the cross-connection, a filler piece, held in readiness for the occasion, is inserted. The removal of the filler piece affords some protection to the public health when the cross-connection is not in use. When the emergency intake or bypass is in use, safeguards such as emergency chlorination and notification to the consumers to boil the water may be adopted but even with these and other safeguards the quality of the water obtained is at least questionable.

The continued existence of these cross-connections is largely for financial reasons. Large expenditures would be necessary in many systems for the construction and operation of extensions to supply works and purification plants.

While it is not always possible to anticipate all contingencies which may necessitate bypassing purification plants, such contingencies can be largely eliminated by proper design and by the use of reasonable foresight. Where emergency intakes or bypasses are required, provision for immediately, adequately and continuously chlorinating the supplies drawn through them must be made. The best practice, however, is to have the water works system so adequate as to need no such intakes or bypasses.

FAULTY PLUMBING AND PLUMBING FIXTURES AND OTHER SPECIAL FORMS OF CROSS-CONNECTIONS

Local pollution of potable water supplies within buildings may be brought about through faulty plumbing arrangements and improperly designed plumbing fixtures. Cross-connections exist in many toilet fixtures such as bath tubs, wash sinks and toilet bowls flushed with direct pressure. Through such connections, backflows of polluted water may occur into the water pipes of buildings as the result of

stoppage, siphonic action or the reversal of pressure head. In 1929, the cross-connection committee of the Conference of State Sanitary Engineers called attention to the hazard of pollution through plumbing fixtures and concluded "that progress could be made in the development of new plumbing fixtures by the designation of this committee or some other committee to represent the Conference in taking up with the plumbing industry the matter of elimination of production of toilet and other fixtures which admit the possibility of pollution of water supply systems." No action, however, appears to have been taken as regards this suggestion other than the coöperation of a committee of the Conference with a Committee on Plumbing of the American Public Health Association. A joint committee of the two associations made a progress report in October, 1930, in which the hazards of water supply contamination through plumbing fixtures is discussed at some length.

The Chicago Board of Health has reported the infection of the water supply in a hospital due to a faulty piping arrangement at the sterilizers. Submerged inlets to sterilizers, direct connections from cooling coils to the waste pipes, and bypasses around sterilizing apparatus were found to menace the safety of the drinking water supply and of the sterilized water supply as well.

At practically all recirculating type swimming pools, cross-connections exist between the public supply and the pool water. The public water drawn through the cross-connection is used for washing filters and for make-up water. As most of the swimming pools are located in basements, it is sometimes possible to supply the public water to the suction side of the recirculating pump, taking care to locate the supply pipe from the street above the highest water level of the pool so that no backflow is possible. Where the recirculating pump is too small to supply wash water at the necessary rate, a wash water pump taking suction from a well arranged tank filled with public water could be installed. There are generally drains from the pool and filter wash water waste directly connected to the sewer. Pollution from this source can be avoided by eliminating the direct connection to sewer and draining the pool and wash water to a sump equipped, if necessary, with a bilge pump.

Overflows from reservoirs, otherwise safely constructed, directly connected to a sewer constitute dangerous cross-connections which will permit contamination by the flooding and backing-up of the sewer. The overflow can be safely arranged by discontinuing the direct

physical connection and discharging through an air gap into a surface drain, which in turn can be connected to the sewer through a catch basin.

Open surge tanks or reservoirs are occasionally installed where potable water from the public supply is to be pumped to high buildings or given additional treatment such as cooling for circulating drinking water systems in hotels. Contamination is possible from external sources. Installations have been found where sewer drain pipes have been thoughtlessly installed above the open receivers. The use of a tight cylindrical steel tank safely vented in place of the open tank or reservoir would permit safe storage.

One particularly interesting cross-connection has come to the attention of this committee consisting of a direct permanent connection between the casing of a sewage sludge pump and a water pipe. In this case, the only protection against contamination was a single valve.

The above examples of miscellaneous and special cross-connections illustrate the numerous ways by which local pollution of potable water supplies may be brought about. One is led to wonder how many cases of infection of obscure origin have been caused by similar cross-connections. Only by proper and rigorously enforced plumbing regulations can such hazards be obviated.

SUMMARY AND CONCLUSIONS

Unprotected cross-connections between polluted private supplies and potable public water supplies are a distinct menace to public health and should not be allowed. The great majority of cross-connections can, and should be, eliminated readily, but a relatively few special cases occur where immediate elimination of cross-connections between private and public supplies is impracticable. In such cases, some safeguard should be provided. The authority to decide as to what cross-connections should be eliminated, when such elimination shall occur and what safeguards shall be required should be vested in the State Health Departments.

Good progress has been made during recent years in the elimination and control of cross-connections and much valuable experience has been obtained. Studies of the water supply needs of individual properties have brought about a better appreciation of the problems connected therewith and experience has shown that prompt correction of unsatisfactory conditions is frequently possible with the co-

operation of owners. More rapid progress, however, could be made by the inauguration of state-wide programs in those states which have confined their efforts to the occasional elimination or protection of a cross-connection.

An inadequate and unreliable water supply acts as a deterrent to the elimination of cross-connections. Water works improvement programs should be inaugurated, wherever possible, to furnish service which will encourage the elimination of additional cross-connections. Dual public potable water services are possible by extensions of high and low pressure systems in a number of cities. Fire protection engineers are concerned primarily with securing adequate water supplies; and today, more than ever before, they are trying to secure such supplies without the use of cross-connections.

Since the adoption of the resolutions of the Fire Protection Division of the American Water Works Association in 1925, new regulations have been about equally divided between those prohibiting all cross-connections and those permitting protected cross-connection. On the whole, there has been a distinct trend towards improvement of conditions.

The field experience with all bronze, rubber seated, double check valves has been encouraging and indicates that when such valves are properly installed and maintained they are the best single protective device yet developed for unavoidable cross-connections. A responsible representative of the water works should test the valves for tightness at least quarterly and should give them an internal inspection and cleaning at least yearly. Additional inspections by the State Department of Health should be made, if possible.

The automatic start and stop chlorinator is a valuable auxiliary protective device available for those installations where some further protection is felt necessary in addition to that afforded by the all-bronze double check valves. Experience with such chlorinators has been largely confined to the few installations in New York State and has been as favorable as could be expected. When the device is properly installed and maintained, it will render moderately polluted secondary supplies bacteriologically safe.

Most of the improvements thus far made have been confined to industrial and fire service cross-connections as they are the larger sized ones, are better known, and have been more widely discussed. Possibilities for contamination of water stored in reservoirs may exist as the result of improper drain and overflow connections and should be

corrected. There is much improvement also to be made as regards cross-connections involving emergency intakes, bypasses around the whole or parts of purification plants, and drinking water supplied from private wells of doubtful character and without supervision. Such bypasses and intakes constitute serious public health hazards and should be eliminated except in special cases where, in the opinion of the State health authorities, they are necessary and properly safeguarded.

Little nation-wide progress has as yet been made with respect to cross-connections involving sewage treatment plants, swimming pools, improper plumbing and improperly designed plumbing fixtures because of the comparatively short time since attention was first called to these connections. Such conditions should be guarded against by suitable plumbing codes, adequately enforced, by improved design of fixtures by the manufacturers and by proper design of swimming pools and of sewage treatment plants.

RECOMMENDATIONS

In view of the above conclusions, the Committee suggests as a policy to be adopted by the American Water Works Association, the following recommendations:

1. (a) That no new cross-connections be permitted between safe and unsafe water supplies, the quality of the respective supplies being determined by the state health authorities.
   (b) That all existing cross-connections between safe and unsafe water supplies be eliminated, except that temporary cross-connections may be continued in use if made through properly installed and adequately supervised, all bronze, rubber-seated double check valves when such connections are approved by the state health authorities, and then only when extraordinary circumstances prevent complete severance. At the discretion of these authorities, the additional safeguard of proper disinfecting equipment for the private supplies should be provided.
2. That deficiencies in the adequacy of public water works systems be corrected in order to hasten the complete elimination of cross-connections.
3. (a) That bypasses around water purification plants and emergency intakes be eliminated in so far as practicable and as rapidly as possible.

(b) That when immediate elimination of such bypasses and intakes is not feasible and in special cases they should be adequately safeguarded in a manner approved by the state and local health authorities.

4. That opportunities for local pollution through improper plumbing installations and equipment be guarded against by a nationally uniform provision relating thereto in plumbing codes and that this Association coöperate with other agencies engaged in attempts to establish proper plumbing regulations.

Respectfully submitted,

E. SHERMAN CHASE, *Chairman.*
For Committee No. 8, on Cross-Connections.

Committee: J. Walter Ackerman, John Chambers, J. I. Connolly, Earl Devendorf, C. W. Mowry, Ralph W. Reynolds, R. E. Tarbett.

APPENDIX A

EXAMPLES OF COMMON CROSS-CONNECTIONS TO POTABLE WATER SUPPLIES

(From Report of Committee on Cross-Connections, New England Water Works Association, February 1929)

A. Cross-connections Where Secondary Supply is Available and Connected:

I. *Fire Service:*

Pipe for:

(1) Sprinklers and hydrants.

(2) Pump priming.

(3) Drinking water taken off sprinkler system or yard mains.

II. *Industrial Use:*

Pipes for:

(1) Boiler feed.

(2) Washing. Examples: paper-making processes; textile industry; tanning industry; dairying processes, etc.

(3) Cooling. Examples: condensers; mills-rubber industry; mills-pyroxylin plastic; bearings; dairying processes, etc.

(4) Quenching. Examples: coal and tar products; wire works, foundries, etc.; metal-finishing plants.
(5) Process work. Examples: dye kettles-textile and leather industries; paper manufacturing; gas manufacture, etc.

III. *Mill Use and Supply of Hotels and Office Buildings:*

Pipes for:

(1) Drinking supply-secondary supply of questionable character.
(2) Toilet supply (especially in case of direct-pressure flushing hoppers and improperly designed plumbing fixtures).
(3) Washing in sinks.
(4) Bathing (including swimming pools).
(5) Hydraulic elevators, lifts, presses, etc.
(6) Pressure regulation.
(7) Injectors.

IV. *Sewers (either direct or indirect through tanks).*

B. Connections to tanks, barrels, cisterns and reservoirs that are filled with chemicals or in which the water is purposely made non-potable preparatory for use in:

Paper industry
Textile industry
Boiler feed
Farming or hot-houses, etc.

In these cases, no secondary supply is used and no pressure exists other than a head due to height of water in receptacle. In the event of negative pressure in supply piping, the water may siphon into drinking-supply mains.

Types of Cross-Connections:

(1) *Physical cross-connections* where dual supplies under pressure are permanently connected—protected usually by gate-, globe- and check-valves with various combinations.
(2) *Temporary connections*—swing joint provided where dual supplies are made available at the point of use but where little possibility exists of polluting potable supply.
(3) *Filler piece*—usually flanged—which, when removed from line, breaks cross-connection but when

actually in place is same as physical cross-connection.

(4) *Open connections*—tanks that are open to atmospheric pressure may be filled from dual supplies:

(a) Where both feed pipes enter bottom and supply pipe taken from bottom-pressure on potable supply due to head of water in tank.

(b) Where polluted feed line enters the bottom-potable feed located above ordinary water level in tank.

(c) Where polluted feed line is located above ordinary water level—potable feed line enters bottom of tank—same as (a).

(ED.—In addition to the above three kinds of permanent fire-service cross-connections, temporary cross-connections are sometimes made by means of hose, so that pumpers or fire boats can discharge non-potable water into fire department connections to sprinkler systems and standpipes.)

APPENDIX B

PARTIAL LIST OF FAILURES OF PUBLIC WATER SUPPLIES

In a pamphlet entitled "Interruptions and Failures of Public Water Supplies," 1930 edition, the Inspection Department of the Associated Factory Mutual Fire Insurance Companies has compiled 405 such interruptions of major importance.

The list is, of course, only partial, especially if the entire country is considered, as no systematic or thorough attempt has been made to collect the data or to get the complete experience in any town or city. Furthermore, the list does not include the almost innumerable cases of necessary shut-offs in single streets or small areas. It is evident that these occurrences, as well as those affecting larger areas, are much more frequent than generally known.

These incidents do not constitute, in the great majority of cases, a reflection on the management or excellence of public water systems. The occurrences simply indicate that even in the larger systems and despite the best of care, interruptions are to be expected.

A few cases illustrating failures from typical causes are quoted:

"*Bristol, Pa., Jan. 1928.*

Anchor ice clogged the single intake pipe supplying all the pumps and put the pumps out of service for three hours and fifteen minutes. Failure of the pumps left the town with only the water in a 170,000 gallons equalizing tank. This was drained in about one hour and fifteen minutes and the town was entirely without water for the remaining two hours till the suction line was cleared and pumps started. An independent suction line, proposed at the time, will reduce the chances of similar trouble in the future."

"*Kendallville, Ind., June 1923.*

Dry weather and the failure of wells supplying the pumps made it necessary to shut off the 500,000 gallons reservoir, the supply at the time having been reduced to 300,000 gallons.

From about the middle of June to about July 10 water was supplied by pumps which were able to maintain but 5 pounds per square inch in the main part of the town.

Pressure for sprinklers or for hydrant use was therefore lacking at the start of a fire or until the reservoir valve could have been opened. Additional wells were completed and normal pressure of 75 pounds was restored about July 10."

"*Lowell, Mass.* (*City Water System*), *Dec. 1924.*

At 9 p.m., December 2, pressure at the city pumping station suddenly dropped from 60 to 20 pounds per square inch. At 9:30 trouble was found to be due to blowing out of a 24-inch plug on a low-service main. Difficulty in finding valves and two large valves found to be inoperative delayed shutting off the water until between midnight and 1 a.m. Water in the meantime undermined a 30-inch low-pressure main and a 12-inch high-pressure main, both of which were broken by the falling of undermined trees. Pressures in the low-service system, which covers most of the city, were too low for effective fire service for three to four hours. Pressures were again practically normal in this system in about 10 hours, the supply being through the remaining 24- and 12-inch mains. A considerable section in the east part of the city was, however, shut off and without water for two days. The intermediate level reservoir connecting with the low-service system was drained and the low-pressure reservoir was somewhat lowered.

The high-service reservoir was practically drained and high-level sections were without water until December 4, when this service was restored. Replacement of the 30-inch main was expected to take several days."

"*North Adams, Mass. Nov. 1927.*

The water system failed at the crest of the flood of November 3, due to the breaking or washing out of five mains (8- to 16-inch) crossing the river. By closing valves, service was restored in a part of the city but much of the business and manufacturing districts and all of the high-service areas were without water supply until the afternoon of November 5, when the emergency pumping station, previously flooded, was started, maintaining 25 pounds per square inch on part of the isolated section. Some areas including several mill properties were still without city water on November 17, and at one plant, having a city

supply only, water was not available until November 26. Plants having private gravity supplies or pumps were able to maintain pressure on their sprinklers systems with little or no interruption. Full repairs were not completed and all service restored until December 21."

"Plainfield, N. J., June 1923.

Unusual draft due to hot dry weather increased beyond the capacity of the pumping station the consumption in Aldine, Garwood and Plainfield supplied by the same water company. On June 25 the reservoir was so low that Aldine and Garwood were shut off from 6:30 p.m. to 6 a.m.

On the following day the reservoir was empty and the Plainfield supply was shut off from 1 to 5 p.m. to allow the water to accumulate in the reservoir. There was, however, less than 18 inches of water in the reservoir on the following day.

Up to about the middle of September there was little improvement and the pumps were not able to accumulate more than 2,000,000 gallons in the 9,000,000 gallons reservoir or probably less than two hours consumption. Later a moderate daily supply of water was available by purchase from a neighboring water company which enabled the reservoir to be maintained practically full."

The causes of the 405 interruptions and failures can be grouped into three general classes: (1), failures at the reservoirs and standpipes; (2), at the pumping stations; and (3), in the distribution systems. The number of interruptions in the three classes were 37, 135 and 233 respectively.

It may be surprising to note that 103 interruptions were caused by the elements,—drought, floods, freezing, excessive hot weather, anchor and needle ice, storms, landslides, and fires at the pumping station. Part of the failures of electric power were also caused by the elements.

APPENDIX C

PARTIAL LIST OF OUTBREAKS OF WATER BORNE DISEASE ATTRIBUTED TO INFECTION THROUGH CROSS-CONNECTIONS, AUXILIARY INTAKES AND BYPASSES

Brief abstracts of 26 outbreaks of water borne disease caused by direct cross-connections are listed. These data, with the exception of the Fort Wayne, Ind. 1929 outbreak, are taken from Appendix "B" of the final report of the New England Water Works Association Committee on Cross-connections.

The typhoid epidemics caused by auxiliary intakes and bypasses, with exception of that at Geneva, New York, are taken from the report of Committee on Cross-Connections Conference of State Sanitary Engineers, June 5–7, 1926.

A. Direct cross connections

Albany, N. Y. Health News, New York State Dept. Health November 21, 1927.

Epidemic of diarrhea followed by 30 cases of typhoid caused by polluted water from industrial supply leaking into city mains. There were three cross-connections, each of which was guarded by one or two gate valves. Industrial supply pressure in excess of city pressure.

Bloomington, Ill., Jan. 1920. Eng. News Record, Vol. 84, 939.

Industrial supply of Chicago and Alton shops cross-connected with city supply. The creek from which the industrial supply was obtained went dry and a 33-inch sewer main was tapped. A leaky valve permitted this sewage to enter the municipal supply. There were 300 to 400 cases and 15 deaths from typhoid.

Circleville, Ohio. 1914. Journal A. W. W. A., Vol. 5, p. 447.

Polluted water from private supply leaked through two gates and two checks into city mains. Forty-three cases and 2 deaths from typhoid.

Cohoes, N. Y., Health News, New York State Dept. Health, November 21, 1927.

Forty-seven cases of typhoid caused by pollution of city supply by Mohawk River water entering through cross-connections with industrial supply. Two gate-valves in series on connection operated once, and city pressure low five times just prior to outbreak.

Elgin, Ill., 1916. Journal A. W. W. A., Vol. 15, No. 5, p. 477.

Leaking valve on cross-connection with a factory supply resulted in 18 deaths. Type of valve not stated.

Everett, Wash., 1923. Journal A. W. W. A., Vol. 15, No. 5, p. 477.

Polluted industrial supply entered through open 6-inch gate. Drop in city pressure caused introduction of polluted water through open 6-inch cross-connection with an industrial supply. Two thousand cases of diarrhea; 77 cases and 11 deaths from typhoid.

Fort Wayne, Ind., 1923. Eng. News-Record, Vol. 92, p. 348.

Leakage by two gate-valves and a check-valve in series on a cross-connection at Penn. R.R. plant caused pollution of city supply. One hundred fifty cases and 22 deaths from typhoid.

Fort Wayne, Ind., 1929. Am. Journal Public Health Vol. 19, No. 9, page 144.

A dual water supply system of the Wabash Railroad was responsible for an outbreak of gastoenteritis and typhoid fever. The railroad secured an auxiliary industrial supply from a nearby river. A gate valve on the cross connection was left open, permitting the discharge of polluted river water into the distribution system. There was no check valve on this cross connection. Fifty-three cases and three deaths from typhoid.

Franklin Furnace, N. J., Eng. News-Record, Vol. 89, pp. 959 and 1045, Vol. 91, p. 429.

An open gate-valve and a check-valve on cross connection between municipal and industrial supplies at N. J. Zinc Co. allowed polluted water to enter town supply, causing 114 cases and 18 deaths from typhoid.

Greystone, R. I., 1917. Bull. R. I. State Bd. of Health, Oct. 1917.
Forty cases of typoid and 4 deaths probably caused by neglect to properly close gate-valves on a cross-connection between polluted industrial supply and drinking-water supply.

Lawrence, Mass., 1903. Jour. N. E. W. W. A., 1922, p. 406.
Leaking check-valve on cross-connection with mill supply caused 43 cases of typhoid.

Lowell, Mass., 1903. Jour. A. W. W. A., Vol. 15, No. 5.
Check valve on cross-connection between municipal and fire supply failed to close after a fire, permitting polluted water to enter city mains. Epidemic of dysentery, followed by 196 cases and 16 deaths from typhoid.

Milwaukee, Wis., 1912. Jour. A. W. W. A., Vol. 6, p. 749.
Public supply polluted by leaking check-valves in cross-connections.

Minneapolis, Minn., 1918. Jour. A. W. W. A., Vol. 6, p. 773.
Leaking check-valves in cross-connections caused 18 cases and 6 deaths from typhoid.

Moline, Ill. Jour. A. W. W. A., Vol. 6, p. 230, 1927.
Factory supply from Mississippi River cross-connected with city supply at approximately 20 points. Investigation showed leaking check-valves probably responsible for typhoid outbreak.

Oswego, N. Y., Health News, New York State Dept. of Health, November 21, 1927.
Many cases of diarrhea and 9 cases of typhoid in a factory traced to pollution of drinking water through cross-connection with industrial supply. Cross-connection protected by two globe-valves and two check-valves in series.

Philadelphia, Pa., 1920. Eng. News-Record, Vol. 84, p. 1187.
Tastes and odors in the drinking water led to an investigation of the piping system at the Philadelphia Navy Yard in 1920. Several leaking single check valves in cross-connections that were shown on piping plans of the Navy Yard were eliminated but the situation was not remedied. An unknown leaky check-valve, later found in an inaccessible place through which polluted river water, used for boiler purposes, leaked into the city system. Many cases of dysentery resulted.

Philadelphia, Pa. Jour. A. W. W. A., Vol. 6, p. 750; Annual Report Bureau of Health, Philadelphia, 1913, pp. 116 and 308.
More than 300 cases of typhoid and many deaths were traced to cross connections. An investigation showed many check valves leaking.

Rockaway, N. J., 1923. Eng. News-Record, Vol. 91, p. 267.
The single check valve on a cross connection between a fire supply and the municipal supply was "stuck open and so encrusted with dirt and rust that the flap could only be moved by the use of a bar." The fire supply was polluted by the effluent from a septic tank receiving excretions of a typhoid carrier. Temporary reduction in pressure caused fire supply to flow into town mains. Forty-one cases and 4 deaths from typhoid resulted.

Springfield, Ohio. 1911 Report, Ohio State Bd. of Health, p. 469.
Leaky check valve caused 12 cases of typhoid.

Sterling and Rock Falls, Ill., 1924–25. Eng. News-Record, Vol. 94, p. 526. Polluted river water leaked by a globe valve and a single check on cross connection in a factory. Twelve cases and 2 deaths from typhoid.

Tiverton, R. I., 1926. Bulletin R. I. State Board of Health, December 1926. Cross connection with leaky gate between drinking water tank and tank on fire supply in industrial plant. Fourteen cases and one death from typhoid.

Van Wert, Ohio, 1913. Jour. A. W. W. A., Vol. 15, p. 477.
Sudden drop in pressure on city supply caused in flow of polluted water from polluted private supply of C. & N. R.R. Shops. Six hundred cases of sickness; 25 cases and 2 deaths from typhoid.

Wausau, Wis. Eng. News-Record, Vol. 92, p. 348.
A factory epidemic in Wausau, Wisconsin, traced to a faulty valve in a cross connection. Other details not given.

Winnipeg, Manitoba., Eng. News-Record 1910, p. 677.
Polluted Red River water was used for secondary fire supply and boiler feed. A leaking valve allowed domestic service to be polluted. Twenty-five cases of typhoid.

Winona Lake, Ind., June 1925. Pub. Health Reports, Aug. 21, 1925.
Leaking valve on cross connection between public supply and a polluted industrial supply.

B. Auxiliary intakes and by-passes

PLACE	YEAR	TYPHOID FEVER Cases	TYPHOID FEVER Deaths	INTESTINAL DISTURBANCES	REFERENCES AND REMARKS
Charleston, Ill.	1925	0	0	3,000	Data by Mr. Ferguson, Ill. (By-pass existed, epidemic by inadequate filtration and failure to chlorinate)
Geneva, N. Y.	1917	15	?	?	1917 Rep. v. 2, N. Y. State Dept. Health, p. 333
Herkimer, N. Y.	1918	155	28	?	Health News, N. Y. St. Dept. 1920
Moline, Ill	1918	125	24	?	Data by Mr. Ferguson, Ill.
Milwaukee, Wis	1916	4,500	40	5,000–6,000	St. Bd. Health Rept. 1916
Neenah, Wis.	1920	19	8	Few	St. Bd. Health Rept. 1918–1920
Schenectady, N. Y.	1900	53	3	?	
Tonawanda, N. Y.	1919	236	?	?	J. A. W. W. A. Vol. 7, pp. 176–8, Mar. 20; Can. Engr. 38; 439, May 6, 1920

APPENDIX D

SUMMARY OF POLICIES OF PUBLIC HEALTH AUTHORITIES

The data given below are compiled from replies to a circular letter sent to each State Department of Health asking for the most recent cross connection regulations. A reply was received from each state except Arizona, Georgia, Idaho, Nevada and Utah.

States reporting	43
States having regulations which prohibit cross connections	13
States having regulations which prohibit cross connections with unapproved surface water supplies but not specifically prohibiting cross connections with unapproved ground water supplies	1
States having regulations which permit cross connections protected with approved type double check valves	9
(Three of these states prohibit *new* cross connections.)	
(Two of these states require chlorination in addition to approved type double check valves.)	
States having no regulations regarding cross connections	20

Most of the states with regulations have been actively enforcing them, although some regulations prohibiting cross connections have not been completely enforced mainly because of insufficient funds and personnel.

Twelve states have made regulations since the resolutions of this Association adopted in May 1925, 6 prohibiting cross connections and 6 permitting protected cross connections.

The large number of states having no regulations does not mean that these states have not been actively at work on the cross connection problem. The policy of these twenty states as indicated in the replies to the circular letter is as follows:

General policy to prohibit cross connections	4
Allow cross connections protected by approved type double check valves	8
Study each case on its merits	2
Few cross connections, if any exist	2
Definite policy not indicated	4
	20

APPENDIX E

RESOLUTIONS ADOPTED BY VARIOUS TECHNICAL SOCIETIES

American Water Works Association

The fire protection division of the American Water Works Association adopted the following resolutions at Louisville, Kentucky, May 1925:

"WHEREAS cross connections between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever and other water-borne diseases, and

"WHEREAS, check valves and other similar protective devices cannot always be depended upon, be it

"*Resolved*, that no physical connection should be permitted between a potable public water supply and any other supply except as follows:

1. With another potable public supply.
2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.

"This prohibition to apply to all piping systems either inside or outside of any building or buildings, and

"*Be It Further Resolved*, that definite programs should be inaugurated in each municipality to permanently eliminate all other connections."

Conference of State Sanitary Engineers

The following resolutions were adopted in October, 1929, by the Conference of State Sanitary Engineers:

"WHEREAS, certain recent developments in the field of cross connections between safe drinking water supplies and other water supplies of a quality unapproved for human consumption by the state or other health authorities having jurisdiction, have led the Conference of State Sanitary Engineers to make a review of the subject of cross connections, and

"WHEREAS, such review shows that notwithstanding the further improvements which have been made in protective equipment and the additional safeguards which have been developed, such cross connections still constitute a possible hazard, and

"WHEREAS, among the many types of cross connections, this review has directed particular attention to the potential dangers from cross connections between safe drinking water supplies, and swimming pools and certain plumbing fixtures,

"*Therefore, Be It Resolved*, that

1. This Conference again desires to go on record as being opposed to the existence of any cross connections between safe drinking water supplies and other water supplies of a quality unapproved for human consumption by the state or other health authorities having jurisdiction.
2. This Conference urges that control of cross connections by state and local authorities be inaugurated in those states where such control does not now exist.
3. This Conference recognizes that inadequacy of municipal water distribution systems is frequently a barrier to complete elimination of cross connections and urges the extensions of such systems to remove this barrier.
4. This Conference recommends that the design of swimming pools be laid out so as to eliminate cross connections with swimming pool waters.

5. This Conference requests the co-operation of manufacturers and those responsible for the installation and control of hospital sterilizers, toilet bowls, wash sinks and other plumbing fixtures, in eliminating the production and installation of equipment where the design is such that under certain conditions of stoppage, pressure change or otherwise, polluted water may contaminate piping systems for drinking water."

New England Water Works Association

The following resolutions were adopted on February 13, 1929, by the New England Water Works Association:

"WHEREAS, evidence shows that the existence of certain cross connections between safe public water supplies and unsafe private water supplies, not equipped with modern protective devices, has resulted in many outbreaks of disease and many deaths, and

"WHEREAS, such cross connections are a hazardous part of any water supply system.

1. This Association recommends that no cross connection be permitted with a supply that in the opinion of the State health authorities is bacterially unsafe.

2. This Association recommends that any cross connection permitted with a bacterially safe but non-potable supply shall be made through a properly installed and adequately supervised, all-bronze, rubber-seated, double check valve of a type approved by the State health authorities."

Maine Water Utilities Association

On April 23, 1930, this Association approved the following suggested regulations and voted that they be presented to the Public Health Council of the State of Maine, with the recommendation that they be adopted and placed in force at the earliest possible date.

Suggested rules and regulations governing cross connections

On and after ——19—, no new cross connections, as defined below, will be permitted to be installed nor will any additions to existing cross connection systems be permitted.

On and before ——19—, all existing cross connections shall be eliminated except as follows: where protected by any combination of the following devices:

(1) Automatic, all bronze check valves installed in pairs under the direction and with the approval of the State Department of Health and inspected monthly by its authorized representative.

(2) Removal sections of pipe or swinging joints sealed in the *"off"* position by the State Department of Health and inspected monthly by its authorized representative.

(3) An open tank, reservoir or standpipe supplied from the approved source through a pipe, the open end of which shall be above the highest possible point which water from the unapproved source may reach. The design of this system shall be approved by the State Department of Health.

All cross connections, except those through the open tank, reservoir or standpipe shall be equipped on the suction side of the pump with automatic chlorinating devices of a type approved by the State Department of Health and operated according to its instructions and regulations. This device shall be installed on the supply line from the unapproved source and shall be maintained in proper working order at all times. Duplicate installations may be required where deemed necessary.

The duty of detecting and reporting to the State Department of Health all installations of cross connections shall rest upon the officers of the person, firm or corporation maintaining such cross connections.

Each person, firm or corporation permitted to maintain a cross connection shall file with the officers of the public water supply organization a bond protecting and saving harmless from all actions for the recovery of damages arising from the introduction of impure or polluted water into the public system through its cross connection, or cross connections.

Penalty for violation

Every person, firm or corporation violating any of the above provisions of this regulation shall be punished by a fine of ——— for the first offense, and not less than———, nor more than ——— for each subsequent offense.

Definition of cross connections

A cross connection shall be defined as any physical connection between a public potable water supply and any private supply used for auxiliary purposes for fire protection, manufacturing processes or any other uses, which is not regularly inspected and approved by the State Department of Health.

A physical connection

Where any two supplies as defined above are connected by means of pipes leading directly from one to the other, flow being prevented by means of gate valves or check valves, removable sections of pipe, swinging joints, or any device through which the flow from the unapproved source may possibly enter that which is approved. By-passes around purification plants or any part thereof are to be considered as cross connections or physical connections.

National Fire Protection Association

The position which the Association takes regarding cross connections for fire service is given in the following statements approved at the May 1928 meeting.

1. The National Fire Protection Association is in full sympathy with the efforts being made to maintain the purity of public water supplies. It rec-

ognizes a public duty in bringing fire protection requirements into harmony with the best public health standards.

2. Fire protection engineers should not advocate cross connections with non-potable supplies for fire service when it is feasible to safeguard life and property in some other way.

3. No fixed rule can be adopted for all situations, and each case must be carefully studied to determine the most reasonable arrangement under the existing conditions.

4. The chance that the best double special check valves properly supervised might, under conceivable conditions, both leak at the same time has been conceded, but experience of eighteen years over a wide field and under many different conditions has shown that this danger is extremely remote. It is, therefore, believed that double special check valves of the latest improved all bronze type can be used under certain conditions with a negligible degree of risk, but only if properly installed and adequately supervised.

5. Public regulations concerning cross connections should have reasonable flexibility so that double special check valves or other equally effective devices properly supervised would be allowed for fire services where conditions justify their use.

APPENDIX F

RESULTS OF INSPECTIONS AND TESTS OF PROTECTIVE DEVICES

Description of all-bronze double check valves

Specifications

The body of the check valve and all working parts shall be of bronze with the exception of the clapper facing which shall be a dome-shaped rubber facing coming to a seat on a wide seat ring and functioning similar to a balloon type automobile tire. Liberal clearances shall be provided between the body and all working parts.

A flanged cast iron spacer shall be provided between the check valves unless space is limited, in which case the checks may be bolted together.

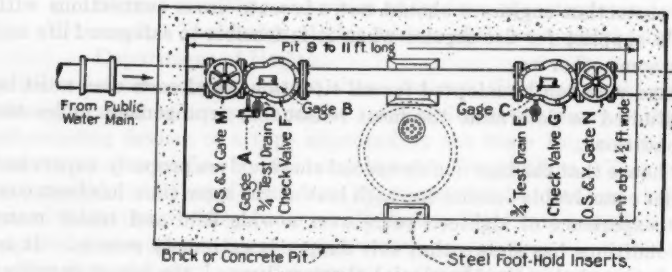
The vault shall be of watertight construction and properly drained.

Method of testing

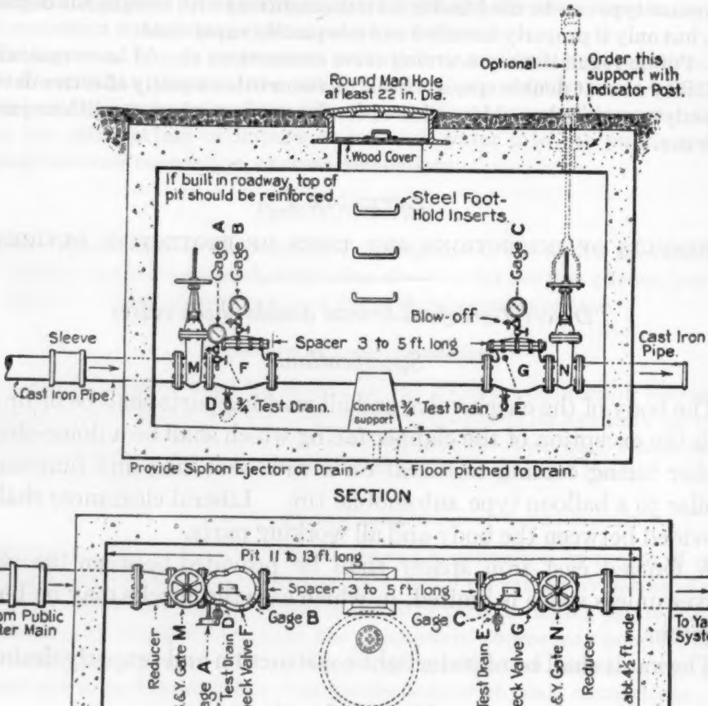
By means of the gate valves, M&N, test drains D&E, and test gages A, B and C, the check valves can be conveniently tested for tightness and for determining if and where a leak exists.

Cleaning

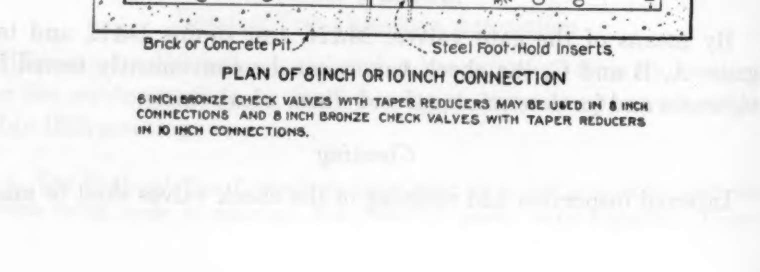
Internal inspection and cleaning of the check valves shall be made



PLAN OF 6 INCH CONNECTION



SECTION



PLAN OF 8 INCH OR 10 INCH CONNECTION

6 INCH BRONZE CHECK VALVES WITH TAPER REDUCERS MAY BE USED IN 8 INCH CONNECTIONS AND 8 INCH BRONZE CHECK VALVES WITH TAPER REDUCERS IN 10 INCH CONNECTIONS.

annually. Rubber facings shall be carefully examined and replaced, if found in any way defective. Facings should be ordered directly from the manufacturer of the check valves.

Tests of double check valves at Naumkeag Mills, Salem, Massachusetts, by the Massachusetts State Department of Health, November and December, 1916

(Public Document No. 34, 1916, pages 118 to 122)

Tests of efficiency of double check valve systems. In November, following a request made several months previously by the Factory Mutual Insurance Companies, tests were begun at the Naumkeag Steam Cotton Mills, Salem, in regard to the efficiency of the double check valve system, so called.

At these mills, as at many others, there is an auxiliary fire supply controlled by the mill and separate from the municipal supply. The object of this auxiliary supply is, of course, to render the property doubly safe in time of fire. The auxiliary supply at the Naumkeag Mills is taken from Salem Harbor. Normally, the mains and sprinkler systems at these mills are filled with water from the municipal supply under about 80 pounds' pressure. The fire pumps of the auxiliary supply are capable of producing 120 pounds' pressure; hence when in use they would force the harbor water into the city mains unless adequate preventive appliances were adopted. This is believed by the insurance companies to be attained by placing double check valves at the entrance of the city mains to the mill yards. These check valves are supposed to work easily and to be closed tightly when the pressure from the fire pumps exceeds the city pressure.

On three separate days, with the fire pumps in operation filling the mains within the mill yard and with two large fire streams working, chemical and bacterial samples for examination were taken on each side of the two check valve systems in use. The pressure on the mill fire system was on two of these days always greater than the municipal pressure, and on the third day, while greater during most of the period of test, was lowered twice to a pressure less than the municipal pressure. Samples for determinations of chlorine and bacteria were taken frequently during the period when the mill fire pumps were working, and the results of these examinations, together with pressure readings, are given in following tables. These results show that dur-

ing these days of tests the valves worked successfully under the conditions existing, and that passage of salt harbor water into the mains on the city side of the check valves was prevented.

No general conclusions in regard to the universal effectiveness and safety of these devices can be drawn from such tests, however. It is only by frequent inspection and tests that the safety of such devices can be assured.

WATER AND SEWAGE LABORATORIES OF MASSACHUSETTS

Naumkeag Mills, Salem, Mass., Nov. 28, 1916

TIME OF COLLECTION	PRESSURE (POUNDS PER SQUARE INCH)		CHEMICAL ANALYSES (PARTS IN 100,000)			BACTERIA PER CUBIC CENTIMETER			B. COLI		
	City side	Yard side	Free ammonia	Albuminoid ammonia	Chlorine	4 days, 20° C.	24 hours, 37°C. Total	24 hours, 37°C. Red	0.1 cc.	1.0 cc.	10 cc.
Lower valve, city side											
	—	—	—	—	—	32	7	4	0	0	+
11.30 a.m.[1]	—	—	0.0040	0.0184	1.11	—	—	—	—	—	—
11.50 a.m.	—	—	0.0090	0.2760	1.09	—	—	—	—	—	—
12.05 p.m.	62	115	0.0080	0.1120	1.12	—	—	—	—	—	—
12.30 p.m.	—	115	0.0076	0.0404	1.09	—	—	—	—	—	—
2.30 p.m.	80	96	—	—	—	160	19	9	0	+	+
2.50 p.m.	80	110	0.0100	0.0320	1.07	220	18	7	0	0	+
3.05 p.m.	79	105	0.0056	0.0324	1.06	240	15	3	0	0	+
3.25 p.m.	81	100	0.0052	0.0272	1.07	165	19	10	0	0	+
3.45 p.m.	80	96	0.0072	0.0348	1.07	132	50	32	0	0	+
4.05 p.m.	80	108	0.0064	0.0308	1.09	121	19	7	0	0	+
Lower valve, yard side											
11.50 a.m.	—	—	0.0090	0.1560	1.08	—	—	—	—	—	—
12.05 p.m.	62[2]	115	0.0120	0.0590	1.12	—	—	—	—	—	—
3.05 p.m.	—	—	0.0112	0.0256	2.49	240	16	9	0	0	+
3.25 p.m.	—	—	—	—	—	260	27	15	0	0	+
3.45 p.m.	80	96	0.0104	0.0284	5.15	310	17	5	0	0	+
4.05 p.m.	80	108	0.0052	0.0248	5.70	320	16	9	0	0	+
Harbor at intake of fire supply											
2.30 p.m.	80	96	0.0240	0.0160	1,735.00	—	—	—	—	—	—

[1] Before flushing

[2] Nozzle.

STATE DEPARTMENT OF HEALTH OF MASSACHUSETTS

Naumkeag Mills, Salem, Mass., Dec. 1, 1916

TIME OF COLLECTION	PRESSURE (POUNDS PER SQUARE INCH)		CHEMICAL ANALYSES (PARTS IN 100,000)			BACTERIA PER CUBIC CENTIMETER			B. COLI		
	City side	Yard side	Free ammonia	Albuminoid ammonia	Chlorine	4 days, 20°C	24 hours, 37°C. Total	24 hours, 37°C. Red	0.1 cc.	1.0 cc.	10 cc.
Lower valve, city side											
12.25 p.m.[1]	81	115	–	–	1.07	76	27	8	0	0	0
12.45 p.m.	80	125	0.0100	0.0260	1.08	111	22	3	0	0	0
1.00 p.m.	80	115	–	–	1.08	134	19	9	0	0	0
1.20 p.m.	80	110	0.0068	0.0232	1.08	98	24	6	0	0	0
1.35 p.m.	77	115	–	–	1.08	139	15	8	0	0	0
1.50 p.m.	78	120	0.0100	0.0244	1.08	161	16	8	0	0	0
2.05 p.m.	78	110	–	–	1.09	156	16	0	0	0	0
Lower valve, yard side											
12.20 p.m.[1]	–	–	–	–	1,680.00	–	–	–	–	–	–
12.30 p.m.	–	–	–	–	–	490	29	7	0	+	+
1.00 p.m.	80	115	–	–	1,675.00	370	108	32	+	+	+
1.35 p.m.	77	115	–	–	1,715.00	530	57	19	+	+	+
2.05 p.m.	78	110	0.0092	0.0224	1,725.00	440	52	24	0	+	+
Upper valve, city side											
11.30 a.m.[2]	–	–	–	–	1.07	–	–	–	–	–	–
1.07 p.m.	–	110	–	–	1.07	–	–	–	–	–	–
1.20 p.m.	–	110	–	–	1.08	169	8	2	0	0	+
1.35 p.m.	–	117	–	–	1.08	77	11	5	0	0	+
1.50 p.m.	–	112	–	–	1.08	24	13	7	0	0	+
2.05 p.m.	–	113	0.0088	0.0220	1.06	74	8	0	0	0	0
2.20 p.m.	–	102	–	–	1.02	96	4	0	0	0	0
2.35 p.m.	–	110	0.0112	0.0228	1.09	42	5	0	0	0	+
Upper valve, yard side											
1.09 p.m.	–	110	–	–	1,740.00	–	–	–	–	–	–
1.35 p.m.	–	117	–	–	–	220	20	8	0	0	+
2.35 p.m.	–	110	–	–	1,770.00	150	20	11	0	0	+
2.55 p.m.	–	113	–	–	–	107	15	9	0	0	+

[1] After flushing through hose to bring salt water up against check.

[2] After flushing with city water.

WATER AND SEWAGE LABORATORIES OF MASSACHUSETTS

Naumkeag Mills, Salem, Mass., Dec. 8, 1916

TIME OF COLLECTION	PRESSURE (POUNDS PER SQUARE INCH)		CHLORINE (PARTS IN 100,000)	BACTERIA PER CUBIC CENTIMETER			B. COLI		
	City side	Yard side		4 days, 20°C.	24 hours, 37°C.		0.1 cc.	1.0 cc.	10 cc.
					Total	Red			
Upper valve, city side									
10.45 a.m.[1]	—	—	1.09	7,600	8	0	0	0	0
11.35 a.m.	80	110	1.09	1,500	85	29	0	0	0
11.47 a.m.	80	115	1.08	450	1	1	0	0	0
12.00 m.	80	118	1.08	500	1	0	0	0	0
12.05 p.m.	82	115	1.08	—	—	—	—	—	—
12.15 p.m.	82	115	—	700	2	0	0	0	0
12.35 p.m.	80	113	1.08	800	19	1	0	0	0
12.55 p.m.	80	120	1.08	1,100	5	0	0	0	0
1.17 p.m.	78	120	1.08	800	1	0	0	0	0
1.26 p.m.	78	125	1.08	—	—	—	—	—	—
Upper valve, yard side									
11.35 a.m.	80	110	1,735.00	—	—	—	—	—	—
11.47 a.m.	80	115	—	340	4	2	0	0	+
12.35 p.m.	80	113	1,640.00	—	—	—	—	—	—
12.55 p.m.	80	120	1,575.00	540	3	0	0	0	+
1.17 p.m.	78	120	1,680.00	—	—	—	—	—	—
Lower valve, city side									
10.50 a.m.	88	95	1.08	1,100	7	0	0	0	+
11.15 a.m.	85	115	1.08	660	2	0	0	0	0
11.35 a.m.	83	110	1.08	360	0	0	0	0	0
11.50 a.m.	84	118	1.08	550	12	1	0	0	+
12.10 p.m.	85	117	1.08	540	2	1	0	0	+
12.45 p.m.	84	113	1.08	500	0	0	0	0	0
12.55 p.m.	82	110	1.09	600	5	0	0	0	0
1.15 p.m.	82	125	1.08	—	—	—	—	—	—

[1] Before starting test.

STATE DEPARTMENT OF HEALTH OF MASSACHUSETTS

Naumkeag Mills, Salem, Mass., Dec. 8, 1916—Concluded

TIME OF COLLECTION	PRESSURE (POUNDS PER SQUARE INCH)		CHLORINE (PARTS IN 100,000)	BACTERIA PER CUBIC CENTIMETER			B. COLI		
	City side	Yard side		4 days, 20°C.	24 hours, 37°C. Total	24 hours, 37°C. Red	0.1 cc.	1.0 cc.	10 cc.
Lower valve, yard side									
11.15 a.m.	85	115	1,780.00	180	10	3	0	0	+
12.10 p.m.	85	117	1,715.00	–	–	–	–	–	–
12.35 p.m.	–	–	–	420	4	2	0	0	+
12.45 p.m.	–	–	–	500	2	1	0	0	0
12.55 p.m.	82	110	3.40[1]	–	–	–	–	–	–
1.15 p.m.	82	125	1.30[1]	–	–	–	–	–	–
Harbor at intake of fire supply									
10.00 a.m.	–	–	–	300	37	16	0	0	+

[1] Fire pumps stopped a few minutes allowing city water to enter.

TESTS OF DOUBLE CHECK VALVES BY CONNECTICUT STATE DEPARTMENT OF HEALTH

January 1, 1927–December 31, 1930

Number of installations of approved iron body special F. M. valves	113
Number of installations of approved all bronze valves	49
Total number of installations	162

TYPE OF VALVES	NUMBER OF INSPECTIONS	NUMBER OF INSTALLATIONS LEAKING ON OUTSIDE VALVE (CITY SIDE)	NUMBER OF INSTALLATIONS LEAKING ON INSIDE VALVE (MILL SIDE)	LEAKING IN BOTH VALVES	BOTH VALVES O.K.	SECOND TEST O.K.†	PERCENT TESTS, 1 VALVE LEAKING	PERCENT TESTS, 2 VALVES LEAKING
Iron body approved type	2,022	37	9	4*	1,972	55	2.3	0.2
All bronze approved type	917	4	1	0	912	3	0.5	0

* These installations were faulty ones and conditions have since been remedied.

† These tests counted O. K. because of likelihood that any flow would flush out sediment existing under quiescent conditions.

RESULTS OF TESTS MADE IN 1930 BY INSPECTION DEPARTMENT

Associated Factory Mutual Fire Insurance Companies of fire service double check valves in factory mutual risks

All-bronze valves

Number of installations	357
Number of tests for tightness	1,407
Both checks tight	1,397
Outside check only leaky	10
Inside check only leaky	0
Both checks leaky	0

Special type F. M. iron body valves

Number of installations	811
Number of tests for tightness	3,028
Both checks tight	2,975
Outside check only leaky	37
Inside check only leaky	15
Both checks leaky	1*

* Cleaned at once by inspector and mill mechanics and both valves left tight.

In addition to the above tests for tightness, each set of double check valves was inspected internally, cleaned and new rubber facings nstalled where necessary. The internal inspections were made by engineers from the Factory Mutual Laboratory who devote their entire time to this work.

When a valve is classed as leaky, it does not mean that water was passing back through the valve, but that, if the pressure on the factory side of the clapper were raised above that on the city side, water might pass through that particular valve, but not through the set as a whole.

The double check valve installations are located in 28 states and Canada.

RECORD OF CHECK VALVE TESTS AT NEW BEDFORD, MASS.
(SUMMARY JANUARY 1, 1931)

Number of Plants having check-valves on city connections	55
Total number of sets of double checks in service, Jan. 1, 1931	82
Classification as to make:	
	Sets
Chapman (Iron Body)	52
Fairbanks (Iron Body)	12
Pratt-Cady (Iron Body)	7

	Sets
G. F. E. (Iron Body)	6
Ludlow (Iron Body)	4
G. F. E. (All-Bronze)	1
Total	82
Classification as to size, inches:	
6	29
8	41
10	12
Total	82

Date installed	*Number of sets*	*Years in service*	*Valve years*
1910	3	20	60
1911	4	19	76
1912	13	18	234
1913	20	17	340
1914	4	16	64
1915	23	15	345
1916	4	14	56
1917	4	13	52
1920	2	10	20
1921	2	9	18
1925	1	5	5
1926	1	4	4
1928	1	2	2
Total	82		1,276

		Years
Period of Service:		
Minimum		2.0
Average		15.6
Maximum		20.0
Total Number of Tests:		
Total	3,377	
Per set	41.2	
Per set per year in use	2.65	
Results of Tests:		
Both leaking (one in 845)	4*	
One leaking (one in 13)	356	
Both tight (one in 1.08)	3,117	
Total	3,377	
Openings for Examination:		
Total	821	
Per set	10.0	
Per set per year in use	0.64	
Once every 1.6 years		

Classification of Causes of Leakage:	Number of times
Corrosion	13
Tuberculation	147
Not seating	53
Gasket poor	36
Obstructions	3
Unstated	8
	260

Note: Leak caused by mechanical defect:
53/260 = 20 per cent of times
Leak caused by tuberculation:
147/260 = 57 per cent of times

Repairs:	
New facings total	232
New facings for each valve 232/84 x 2 = 1.4 for 15.6 years.	
Once in every 11 years	
New clapper arms	31
Repaired clapper arms	44 times in total time

* Two tests reported "both leaking" in recent years occurred in the same set of checks on successive tests and were reported "Slightly Leaky."

STATEMENT REGARDING EXPERIENCE OF NEW YORK STATE DEPARTMENT OF HEALTH WITH FIRE PUMP CHLORINATORS

By Mr. Earl Devendorf, Associate Director, Division of Sanitation

January, 1931.

"There have been 68 fire pump chlorinators installed at 56 industrial plants in New York State, to treat the auxiliary fire supplies of these industries, which have cross connections with public potable water supplies, on which all bronze double check valves have been installed. These protective devices have been provided to comply with the provisions of the State Sanitary Code relating to cross connections between potable public water supplies and auxiliary polluted industrial or fire supplies.

"A majority of the fire pump chlorinator installations have been in service approximately two years. Monthly reports on the daily results of tests and observations of the chlorinators received by the Department indicate that the fire pump chlorinators have, with minor exceptions, operated quite satisfactorily. Inasmuch as these chlorinators were a new development it was expected that there might develop certain features which might not be altogether satisfactory, and which would necessitate adjustment. There have been only a few instances, however, where such conditions have occurred and where they have, it has been possible to determine the cause and correct the same.

"As an illustration of such a condition may be cited the case of the change in the type of chlorine pressure reducing valve with which the earlier chlorinators were equipped. This type of valve was in use on the vacuum feed chlorinators for several years past and it gave very satisfactory service, although it required occasional cleaning to prevent binding at the hinge points. When used under the conditions pertaining at fire pump installations, any sluggishness of the valve became more noticeable than where the machine is being operated manually and a considerable flow of gas was passing through the apparatus. A new type of chlorine reducing valve was developed which was found to obviate this difficulty in operation.

"Again, in the beginning, it was felt that a definite loss in weight of the chlorine cylinders should be indicated by the scale readings. It was found, however, that because of the lack of sensitiveness of the scales, it was impossible to accurately weigh the chlorine cylinders to show definite and daily, regular losses in weight of the chlorine cylinders without some difficulty. Experience has shown, however, that so long as the auxiliary injector discharge shows a good chlorine residual as indicated by the daily tests, it is evident that the apparatus is operating satisfactorily and is, therefore, in readiness to function in case the fire pump is operated.

"Again, the formation of ice in the bell jar was found to be of some trouble, but this condition was largely overcome by simply installing a 100 watt electric bulb in the base of the chlorinator on the chlorine inlet line. A special type of electric heater has since been developed for this purpose. There have, however, been but few instances where such conditions have occurred and where they have, it has been possible to determine the cause and correct the same.

"As a result of two years' supervision of operation of the fire pump chlorinators installed in this state, it appears that this type of equipment has operated with equal satisfaction to apparatus installed and maintained to treat public water supplies and, in general, has been given satisfactory attention and careful operation. The apparatus, if properly maintained and operated, has been found capable of satisfactorily chlorinating auxiliary water supplies in intermittent operation and render such auxiliary supplies bacterially safe, provided they are only moderately polluted.

"In conclusion, the operation of the fire pump chlorinators on industrial fire supplies in this state has, in my opinion, been all that could be expected. While there were a number of adjustments necessary, as there would be in any new piece of equipment, the apparatus has, in general, been given satisfactory supervision and where such supervision and maintenance has been proper, the equipment has functioned effectively."

Appendix G

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CORRECTION

COST OF SERVICE PIPES

In the December, 1932, issue of the JOURNAL, pages 1820 and 1821, tables 1 and 2 were in error in the original manuscript. The column totals in these tables show costs as per foot. These should be in costs per *service*. The revised tables are shown below, with the length of service pipe included and revised costs of materials for lead and copper given in table 2.

TABLE 1 (Revised)

Comparative cost for various metals in services

23 FEET OVERALL LENGTH; 20 FEET HORIZONTAL LENGTH	GALVANIZED STEEL	AA LEAD	B LEAD	COPPER TUBE	COPPER I.P.S.	BRASS I.P.S.
1. Screw taps and tail piece		0.66	0.66	0.66		
2. Lead connections complete	1.24				1.24	1.24
3. Pipe	1.20	5.64	3.62	1.61	3.70	3.47
4. Fittings	0.09				0.24	0.24
5. Nipples	0.18				0.50	0.45
6. Curb cock	0.26	0.66	0.66	0.66	0.26	0.26
7. Total material	2.97	6.96	4.84	3.85	7.54	6.79
8. Labor	5.00	5.00	5.00	5.00	5.00	5.00
9. Cartage	0.50	0.50	0.50	0.50	0.50	0.50
10. Paving	3.75	12.00	12.00	12.00	3.75	3.75
Total cost, dollars per service	12.22	24.46	22.44	20.43	15.19	14.91

TABLE 2 (Revised)

Cost of services—Mt. Vernon Park, sandy clay soil, no paving

Average length of service, 23.3 feet

	GALVANIZED STEEL	AA LEAD	B LEAD	COPPER TUBE	COPPER I.P.S.	BRASS I.P.S.
Material pipe	1.40	**6.37**	**4.09**	**1.82**	3.70	3.47
Lead connection	1.24				1.24	1.24
Screw tap		0.66	0.66	0.66		
Curb cock	0.26	0.66	0.66	0.66	0.26	0.26
Fittings	0.09				0.24	0.24
Nipples	0.18				0.50	0.45
Total materials	3.17	**7.69**	**5.41**	**3.14**	5.94	5.66
Labor	4.21	4.21	4.21	4.21	4.21	4.21
Cartage	0.02	0.02	0.02	0.02	0.02	0.02
Paving						
Total cost, dollars per service	7.40	**11.92**	**9.64**	**7.37**	10.17	9.89

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Penetration Tests Give Bearing Power of Deep Subsurface Soils. GEORGE PAASWELL. Eng. News-Rec., 106: 570–2, April 2, 1931. Preliminary borings indicated that material under Houston-Essex St. subway, New York City, was generally sand, graded from very fine to very coarse, down to rock at considerable depth below surface. This fact simplified soil exploration, as settlement in sand is function of density and takes place under given load practically instantaneously. Device developed to measure density and probable settlement is described and results obtained and their application are discussed.—*R. E. Thompson.*

Equipment's Place in Tunneling Progress. JOHN S. MACDONALD. Eng. News-Rec., 106: 601, April 9, 1931. Brief general discussion. Adoption of modern mechanical tunneling equipment has had an effect beyond that produced by the individual tool; it has created a higher-grade and much more efficient tunnel worker. The combination of dependable and economical equipment and well-trained efficient crews has advanced the art of tunnel construction to its present stage and brought the building of tunnel projects within practicable economical limits.—*R. E. Thompson.*

Tunneling Equipment. I. Development of the Rock Drill. C. H. VIVIAN. Eng. News-Rec., 106: 602–4, April 9, 1931. History of the rock drill, types at present in use, and accessories are discussed. Modern drill weighs from one-fourth to one-third as much as 1900 model and will perform from 3 to 10 times as much work. Air requirement, based on drilling speed, has been considerably reduced. Problem of further progress is one of metallurgy rather than of engineering design. Speeds of from 1800 to 2400 blows per minute are now the rule. Experimental drills have demonstrated that, using high air pressures, much higher speeds are possible, but more enduring steels must be developed to make such drills practicable. It would appear that prevailing standard air pressure of between 80 and 100 pounds will be adhered

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

to for some time. Higher speeds and increased rotative power have placed added emphasis upon lubrication. Correct heat-treatment and reconditioning of drill steels materially prolong their service life. Advantages of machine-sharpening include: increased service between sharpenings, ranging up to 35 percent; increased drilling speed, up to 50 percent; less breakage; decreased wear; and easier handling. Air-operated sharpeners are universally employed. Oil-burning heat-treatment units which can be adapted to gas are usually employed. Pyrometer control of furnaces has been introduced with some success in recent years. **II. Water-Handling Equipment for Tunnels.** A. H. Borchardt. Ibid., 605–7. Discussion of selection and installation of pumping units and of characteristics of several types of units. Compact air-driven single-piston units and electrically-driven centrifugal and power pumps are most frequently employed. Development of vapor-, moisture-, and explosion-proof motors and availability of completely enclosed starting apparatus has increased reliability of electric drive. Diagram is given showing relationship of head, capacity, speed, efficiency, and horsepower for centrifugal unit. Extreme care should be exercised in selecting main-shaft pumps. If pumps are properly designed to allow settlement of sediment and to maintain low water velocity to pump suction, life and efficiency of pumps will be prolonged. It is good practice, where capacity is sufficient, to install 3 pumps, any 2 of which are capable of handling normal flow. No one type of unit will meet even the majority of conditions to be faced in tunnel work. **III. Ventilation During Construction.** R. H. Rogers. Ibid., 608–10. Discussion of ventilation systems employed, fundamental design considerations, and equipment, together with brief descriptions of methods in use on specific tunnel projects, including New York City water tunnel number 2. Data on 32 tunnels here and abroad given recently in Explosives Engineer include following summary: 72.9 miles was ventilated with positive displacement blowers; 32.9 miles with fan blowers; 29.2 miles with centrifugal blowers; 26.5 miles not classified. The squirrel-cage type motor, having fewest parts, no insulation on rotor, and no moving electrical contacts, will, in long run, give less trouble than any other type. **IV. Air-Compressing Equipment and Accessories.** J. F. Huvane. Ibid., 611–3. Discussion of present status of compressor development and of operation and maintenance of accessories. In selecting type of equipment, salvage value should be considered in addition to requirements of particular undertaking involved. Diesel-engine-driven units of stationary type have made rapid strides and economy and reliability of Diesel drive have been amply demonstrated on many large projects within past few years. Any intelligent mechanic can be quickly schooled in proper care of the engine. Use of aftercoolers, which condense and deposit moisture from hot compressed air, has gained marked impetus within last few years due to improvements in design. Material reductions have been made in their size, weight, and cost, and cooling water requirements have also been greatly diminished. Aftercooler should be located between compressor and air receiver, preferably indoors, to guard agaiust freezing, and both cooler and receiver should be drained at least daily. Air filters in compressor intake lines, by keeping dirt and grit out of cylinders and valves, greatly prolong life of these parts and lessen attention required. Use of unsuitable, and of

excessive amounts of, lubricating oil in cylinders should be avoided. Table is included showing oil requirements of cylinders of various sizes. The portable compressor has been developed into a simple reliable unit. **V. Progress in Tunnel Mucking and Haulage.** DANIEL J. O'ROURKE. Ibid., 613-6. Mucking and haulage are of prime importance in planning for tunneling speed and low cost. Various types of equipment employed on these operations are described and their development outlined. The scraper-type loader, used for some years in mining, is now being successfully employed on tunnels up to and including sizes common to single-track railroad tunnels. Characteristics and operation of this type of loader are described and discussed in some detail. Aside from economy of operation, this machine has advantage of not being limited as to part of heading in which mucking can be started. **VI. Evolution of the Concrete Lining Plant.** J. H. FITZGERALD. Ibid., 616-9. Development of various parts making up concrete lining plant is described and discussed, and 2 modern concrete plant layouts are outlined.—*R. E. Thompson.*

Driving and Lining a 6-Foot Tunnel in Gravel. W. B. McMILLAN. Eng. News-Rec., **106**: 645-6, April 16, 1931. Tunnel driving in fine gravel and hand shoveling methods for placing concrete lining were features of construction on recently completed conduit to bring water to Port Angeles, Washington. Hand method of placing was selected primarily because of advantage of being able to speed up this part of work by means of additional crews and inexpensive and easily made forms built on job. New water supply is derived from Elwha River. Conduit capacity is 65 million gallons per day, upper works and tunnel sections being designed for ultimate supply of 100 million gallons per day. From intake in river, first 900 feet of conduit is tunnel, followed by about 2000 feet of open canal. Next section consists of about 1 mile of 72-inch wood-stave pipe and the major tunnel, 1¼ miles long and 6 feet in diameter. From lower end of tunnel, 57-inch concrete pipe conveys water along beach to distribution system. Intake tunnel was driven through rock of variable formation and presented no unusual difficulties. In lower tunnel, it was expected that bore would be through cemented gravel, but material actually encountered for more than 1 mile was fine sand interspersed and stratified with loose pea gravel. Methods employed under these conditions are described. Concrete was premixed and transported by truck, maximum haul being about 7½ miles. Introduction of a creosote water-proofing fluid appeared to improve workability. Tests showed that strength of concrete hauled 7½ miles was 94 percent at 7 days and practically 100 percent at 28 days as compared with that of concrete mixed at site.—*R. E. Thompson.*

New York Aqueduct Construction—Safe or Unsafe Tunneling H. W. RICHARDSON. Eng. News-Rec., **106**: 739-41, April 30, 1931. Press charges that New York City water tunnel No. 2, now under construction, from Yonkers to Brooklyn, is unsafe and that work is being driven at reckless speed, resulting in heavy accident toll, are reported as unfounded. Undue speed, or methods that subordinate safety to progress, is not being employed. Advertised in 4 sections, entire tunnel, totaling 105,280 feet, was let to one contractor

at price close to $43,000,000. Nineteen shafts have been sunk to tunnel grade, and from 16 of these 29 headings have been driven. Up to 3000 men have been employed on tunnel at one time. Work has been under way 2 years, and on April 20th tunnel excavation was 85 percent completed. During that time accidents resulting in 44 fatalities have occurred, 22 of which were caused by rock falls. Bad rock conditions have been most prolific source of serious accidents, size and great depth of tunnel being contributing factors. Excavated diameter is from 19 to 25 feet and depth below surface ranges from 380 to 780 feet. Finished tunnel section is circular, 15 to 21 feet in diameter. Seamy, folded, and blocky rock has been encountered at many points; faults, both major and minor, are common. Brief details of rock conditions, tunneling procedure, and safety program are given, together with analysis of fatalities. Elaborate safety system is employed, medical department consisting of 9 full-time doctors and 1 first-aid man. Only 2 fatalities have occurred as result of failure of equipment. Eleven accidents were due to failure of human element; eight were due to dynamite explosions.—*R. E. Thompson.*

Fatal Chicago Tunnel Fire Confined to Timbering Behind Concrete Lining. Eng. News-Rec., 106: 701–2, April 23, 1931. Eleven men, 4 firemen and 7 workmen, lost their lives in fire that started on April 13th in concrete sewer tunnel under construction for Sanitary District of Chicago. Fire was confined to timbering, 3- x 6-inch maple cants, in place between clay tunnel walls and concrete lining of completed section near shaft. There was no blaze, loss of life being due to suffocation or asphyxiation. Tunnel is of horseshoe section, 17 feet high and 17 feet wide, and at point of disaster there was 20 feet of cover on completed line. Brief details given.—*R. E. Thompson.*

Safety Measures Recommended by Chicago Tunnel Fire Jury. Eng. News-Rec., 106: 744, April 30, 1931. Recommendations designed to insure safety of tunnel workers and to prevent recurrence of fire such as recently occurred in 22nd St. sewer tunnel of Sanitary District of Chicago were presented by coroner's jury inquiring into that disaster. Jury reported that fatalities (11) were caused by asphyxiation by carbon monoxide resulting from fire of undetermined origin. Construction is being held up while recommendations are being carried out. Jury consisted of 3 engineers, 1 chemist, and 2 merchants. Recommendations are listed.—*R. E. Thompson.*

84-Inch Concrete Water Conduit in Baltimore. Eng. News-Rec., 106: 670–1, April 16, 1931. Unit prices are given from contract ($1,145,878) let in February, 1931, for reinforced concrete pressure pipe conduit from new filtered water reservoir at Montebello filtration plant to end of existing 60-inch cast iron main from Druid Lake. All work is in tunnel, 14,000 linear feet, with 6 shafts. —*R. E. Thompson.*

Filters and Pumping Station Connected by Tight Concrete Conduit. William C. Mabee. Eng. News-Rec., 106: 690–2, April 23, 1931. Water supply of Indianapolis is derived principally from surface sources, supplemented

by deep wells. White River filter plant supplies 42 million gallons per day and development to 76 million gallons per day is contemplated. A 48-inch monolithic reinforced-concrete conduit built in 1903 conveys effluent from original filter plant to pumping station 1 mile distant. Supplementary line of precast reinforced-concrete pipe recently completed consists of 4400 feet of 60-inch and 700 feet of 54-inch copper-bell type pipe in 12½ foot lengths, 6 inches thick, molded in steel forms. Flanged sheet-copper cylinders were cast in pipe bells to provide for expansion and contraction, and to take up inequalities of grade in ditch. Ground water was unusually high during construction due to heavy rains. Quicksand was encountered where line crosses Fall Creek, necessitating driving piles 24 feet to reach bearing. Pipe was incased in concrete at crossing, with at least 1 foot of cover in streambed. Water table was lowered in deep section in station grounds by means of well points. Upon completion, gates at either end were closed and leakage test conducted under head of 25 feet for period of 6 hours by feeding water into pipe through calibrated ⅝-inch meter. Gate leakage was measured in buckets. Leakage tolerance for 4,372.4 feet of 60-inch pipe was 9,937 gallons per day and measured leakage was 7516 gallons, equivalent to 151 gallons per inch diameter per mile per day. Comparable results were obtained on 54-inch section. Observations indicate pipe coefficient (Hazen and Williams formula) of 150. Line was equipped with remote control Venturi meter and remote control gates.—*R. E. Thompson.*

Design Features of a 90-Foot Circular Low-Lift Pumping Plant. Eng. News-Rec., 106: 468-72, March 19, 1931. A circular substructure with outside diameter of 90 feet and total depth of 108 feet will house low-lift pumping equipment at new Springwells project of Detroit Water Department. The 8-foot concrete wall of structure was sunk as an open caisson from bottom of 25-foot excavation through 53 feet of clay and 12 feet of hardpan. Eight vertical motor-driven centrifugal pumps of 420 million gallons per day total capacity, supported on floor 74 feet below main floor level, will pump raw water from 12-foot supply tunnel to mixing chamber of filter plant. Between outer wall of structure and 3½-foot inner shell there is a 5-foot annular space which serves as suction and surge chamber and also provides space for vertical concrete discharge flumes. Surge space overflows into raw water conduit to filter plant. Superstructure is to be rectangular, integral with that of adjoining high-lift plant. The 11-mile tunnel to convey raw water from new intake in Detroit River to new plant is rapidly nearing completion. Preliminary estimates indicate average daily demand by new service district will be 197 million gallons per day in 1940 and 206 million in 1950. As experience has shown that ratio of maximum-day to average-day demand in Detroit has limiting value of 1.35, maximum demands will be 266 and 278 million gallons per day respectively. Before deciding on motor-driven equipment, studies were made of installation and operating costs of steam turbines, water turbines, and electric motors for driving centrifugal pumps. Problem of obtaining economical control of quantity delivered was solved by providing some few units with slip-ring induction motors, subject to speed control, remaining units being driven at constant speed by synchronous motors. Use of direct-

current motors was also considered, but rejected as being less economical. Circular-plan structure was selected owing to high soil pressure. Construction methods are outlined. Plant was designed by engineering division of water department.—*R. E. Thompson.*

Contractor Finances Municipal Water Supply Development. ROBERT T. JACOBSEN. Eng. News-Rec., 106: 734, April 30, 1931. Original water works of Havre, Montana, deriving supply from 96 2-inch driven wells, was constructed by city in 1905. Ten 8-inch wells were added in 1918–1920. In 1929, 3 new wells, equipped with deep well turbines, were put in service under contract, payment by city to be made monthly from earnings over period of 240 months, with option of outright purchase at any time on certain agreed terms. As long as contract is in force, city is to manage, control, and operate plant and to pay contractor 4.83¾ cents per 1000 gallons pumped, up to total of 14 million gallons per month, and 4.842 cents per 1000 gallons over that amount. If power consumption exceeds 1 kilowatt-hour per 1000 gallons, deduction at rate of 0.87 cent per kilowatt-hour on such excess may be made from monthly payment. City may become full owner at any time at base price of 2.375 cents per gallon per day producing capacity at time of purchase, but with limit of 3 million gallons as maximum capacity to be paid for. Purchase price is to decrease 5 percent each year that elapses before exercise of option. Assuming annual pumpage of 200 million gallons, city would pay $9,675 yearly, or $193,500 for full 20 years of contract. Maximum annual power cost would be $3,440 and labor cost, $400. Total cost, therefore, would be about $13,500, or 6.7 cents per 1000 gallons, including depreciation, repairs, replacements, and alterations.—*R. E. Thompson.*

Taste and Odor Tests of Paints for Water Tanks. GEORGE L. HALL. Eng. News-Rec., 106, 725 (1931). Results of tests conducted at Maryland Bureau of Sanitary Engineering on 7 types of paints for interior of water tanks are tabulated. Paints were tested by applying to clean vessel and, after thoroughly dry, allowing tap water, distilled water, and water containing various amounts of free chlorine to stand in vessel for 15 minutes. Water was then removed and tested for taste and odor. Most paints having coal-tar base impart objectionable tastes and odors to water.—*R. E. Thompson (Courtesy Chem. Abst.).*

Managua: Its Construction and Utilities. HENRY WELLES DURHAM. Eng. News-Rec., 106: 696–700, April 23, 1931. Managua, capital of Nicaragua, was destroyed by earthquake and fire on March 31st. Buildings collapsed and water supply was completely disrupted. Up until 1928, public water supply was derived from collecting galleries and shallow wells near shore of Lake Managua, to which, doubtless, effluents percolating from city's numerous cesspools found their way. Duplex double-acting steam pump with wood-fired boiler and maximum capacity of less than 1 million gallons per day delivered water through rusty 8-inch cast iron main and limited distribution net of small pipes. Probably only half of water pumped was delivered, owing to leakage. Population at time of quake was nearly 40,000. In 1925, government entered into contract with New York company for sanitation of city,

including new water system deriving supply from Lake Asososca, a crater lake 240 acres in extent with maximum depth of 900 feet. Lake, level of which is very constant, is virtually a deep well supplied by underground drainage from hills to south. Pumping station, consisting of 2 Diesel-engine-driven centrifugal pumps, was constructed at edge of lake, with force main up rocky cliff to 1 million gallon reinforced concrete reservoir 300 feet above, which fed distribution system by gravity. About one-third of streets had been provided with new mains. Financial depression and change of government, however, terminated the work. Earthquake buried pumping plant under landslide, but did not damage reservoir. Damage to pipe line seems to be limited, but most of house connections were broken.—*R. E. Thompson.*

Honeycomb Gravity Dam Proposed. Eng. News-Rec., 106: 719, April 30, 1931. Cellular gravity dam design is advanced (Civil Engineering, April, 1931) by C. E. GRUNSKY to meet demands for improved safety and economy in dam construction. Essential feature of design is the gallery or cell system, which saves material and drains interior of dam, and, in addition, affords cooling surface to dissipate heat generated in setting of concrete. To assure watertightness, metal diaphragm is built in near upstream face. Preferably, this face would be inclined in order to utilize water pressure for stability and to keep foundation load central, both of which effects tend toward economy. Illustrated.—*R. E. Thompson.*

Cofferdamming the Columbia at Rock Island. Eng. News-Rec., 106: 716–9, April 30, 1931. Work of locating, designing, and building two timber-crib structures with aggregate length of about 1500 feet and maximum height of 58 feet for Rock Island dam project of Washington Electric Company on Columbia River was completed in 70 days, with only one day to spare before river reached flood stage. Construction methods are described in some detail. —*R. E. Thompson.*

The Problem of Saline Drinking Waters. IRA S. ALLISON. Science, 71: 559–60, 1930. From Chem. Abst., 24: 3844, August 10, 1930. In course of ground water survey of northwest Minnesota, author observed deleterious effects from waters of moderate concentrations, similar to, but mostly lower than, those reported by HELLER and LARWOOD (cf. C. A., 24: 2186). Worst waters were those rich in sulfate. These waters are commonly but incorrectly referred to as "alkali" waters. Nine samples from various depths and localities in Stevens County range in salinity from 664 to 2800 p.p.m. (average 1575 p.p.m.) anhydrous salts. Minimum sulfate is 29 percent, maximum, 58, and average, 49, or 770 p.p.m. Other averages are calcium 14, magnesium 5, sodium 11, potassium 2, carbonate (including bicarbonate, recalculated) 16, and chloride 1. In 4 samples sodium is higher than calcium. In Cretaceous waters which are tapped by drilling the Red River Valley farther west, sulfate and chloride (apparently connate) are both abundant. Water from city well at Wheaton, Minnesota, shows total salinity of 2794 p.p.m., calcium and magnesium 1 percent, sodium 33, potassium 4, carbonate 4, sulfate 28, and chloride 30. This is a typical soft salty water of region. Similar waters occur

in basal sand of Cretaceous rock system northward to Canadian boundary, but with salinity of 10,000 or more. Towards east these waters are diluted and become sodium or calcium bicarbonate waters. Waters from glacial drift above Cretaceous beds are solutions of calcium or sodium bicarbonate, but may also show high sulfate. Waters from wells ending in clays of glacial Lake Agassiz are very high in sulfate; they have bitter taste and drastic purgative effect. A 45-foot well furnishes water containing 2104 p.p.m. sulfate in total salinity of 3600 p.p.m. An 80-foot well delivers water with 3590 p.p.m. sulfate in total salinity of 5756 p.p.m. Cattle drinking these waters develop run-down, ragged appearance and many eventually weaken and die prematurely. Degeneration of bones sets in, most of lime being abstracted. These bones are reduced to a gristle that can be tied in knots and easily punctured with knife. Calves are stunted in growth and may never mature. Cows develop strange appetites for bones, leather, wood, etc. Alleviation but not cure is effected by feeding bone-meal or ground limestone. About one-quarter of state is thus affected. Questions of human physiology and diet may be involved but perhaps in different degree.—*R. E. Thompson.*

Water Softening at Western Springs, Illinois. L. R. Howson. The American City, **46**: 2, 83–84, February, 1932. Public water supply of Western Springs, Illinois, has total hardness of 900 p.p.m., about 60 percent of which is permanent. Use of this water for household purposes requiring soap has been almost impossible. In addition, it carries an iron content of 3.5 p.p.m., resulting in discoloration of fixtures and the like. Four types of treatment for this water were studied and finally a lime and soda-ash plant with single-unit mixing chamber, settling basin, and carbonating basin was recommended. Plant, as now nearing completion, consists of aëration for the removal of carbon dioxide, followed by quick mix with lime and soda accompanied by violent agitation, slow mechanical mixing and stirring, subsidence in mechanically-cleaned coagulating basin, recarbonation, and filtration through sand. —*Arthur P. Miller.*

Activated Carbon Removes Tastes and Odors from Saginaw Water. Alfred Eckert. The American City, **46**: 2, 90–91, February, 1932. Activated carbon has been applied at Saginaw, Michigan, both to the water going from clarifiers to settling basins and to settled water on its way to filters. Satisfactory results have been obtained following application at either point. At present, greater part of the carbon is fed to effluent of clarifiers, thus permitting carbon to settle out in the basins in order to stabilize the sludge. Saginaw experience indicates that it is desirable to apply carbon at such points that it may be distributed throughout entire body of water in process of purification. It has been suggested that storage be provided for wash water from the filters, to permit its uniform return to incoming raw water. Four different grades of powdered activated carbon have been used and results obtained with cheapest grade were as good as those with higher quality. In using carbon on surface of filters, denser carbon would probably give equally good results and Saginaw authorities are not yet convinced that it would not be as effective in the clarified water. A disadvantage of powdered activated carbon is, that once

successful treatment has been accomplished, there is a definite hesitation to reduce the dosage. Hence unnecessarily high carbon dosage for part of the time is a distinct possibility.—*Arthur P. Miller.*

Oxygen in Eutrophic and Oligotrophic Lakes (Der Sauerstoff in eutrophen und oligotrophen Seen). THIENEMANN, A. Die Binnengewässer, **4**: Schweizerbart, Stuttgart, 1928; Intern. Rev. ges. Hydrobiol. u. Hydrog., **1929**, 23, 152. Studies of different investigators on oxygen deficit in deep water layers is discussed. In 1915 author pointed out the importance of the proportion which the amount of water below the metalimnion bears to that above it; for, given approximately equal depths of epilimnion, lake with greater depth hypolimnion will, owing to lower concentration of oxygen-destroying organisms, have smaller oxygen deficit than that with lesser. Total oxygen content and relation between the layers can be calculated by finding oxygen-contents both of upper 10-metre layer and of water below that layer; deficits in different layers can be calculated by deducting oxygen found from that required for saturation at average temperation of layer. Oxygen relations in different lakes were examined. In Lake Constance total oxygen content and relation between hypolimnion and epilimnion varied little. Oxygen balance in such oligotrophic lakes is more dependent on temperature than on organisms. In eutrophic lakes, like Lake Mendota and the Furesee in Denmark, seasonal variations both in total quantity and in relative proportion of the layers were large. These variations are caused by biological action and only indirectly influenced by temperature. Certain lakes of character intermediate between oligotrophic and eutrophic show winter oxygen supersaturation. Oxygen relations within the metalimnion of oligotrophic and eutrophic lakes are discussed. In eutrophic lakes, oxygen and temperature curves take almost parallel courses. Increasing viscosity of metalimnion with falling temperature and possible effects of currents, wind, turbulence, and respiration of zooplankton are discussed. Author seeks from results of series of observations to prove that oxygen relations between different layers of eutrophic and oligotrophic lakes can be deduced from conditions prevailing at time of highest summer stagnation. Morphometric data required for comparison in such a study of lakes are discussed. Crater lakes in the Eifel and several Alpine lakes are discussed. In case of Lake Zürich, morphometric observations show it to be oligotrophic, while in its oxygen relationships it is eutrophic. This divergence is caused by riparian population. In conclusion, author states that plankton population in a lake is dependent upon formation of its basin and that relation between morphometric and biological properties of a lake can be expressed in fixed numerical values. Morphometrical observations are of increasing importance for biological studies.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Colorimetric Determination of Iron in Drinking and Effluent Waters by Sulphosalicylic Acid. L. N. LAPIN and W. E. KILL. Zeitschrift für Hygiene, 112: 719–723, 1931. Chemistry and Industry, 51: 2, 50 B, January 8, 1932. To 10 cc. of sample are added 2 cc. 2 N ammonium chloride followed by 2 N

hydrochloric acid sufficient to turn Congo paper blue, 2 cc. 20 percent sulphosalicylic acid and 2 cc. 10 percent ammonia. Rose red color is compared with standard ferric solution. Where ferrous and ferric ions both present, above solution is made alkaline with ammonia and total iron determined by intensity of yellow color. Method is sensitive to 0.0002 gram of ferric iron. Nitrites interfere, but not either calcium or magnesium salts.—*W. G. Carey.*

Employment of Phosphate in the Purification of Boiler Feed Water. H. Stäckler. Wochenschrift für Brauerei, **48:** 471–472, 1931. Chemistry and Industry, **51:** 2, 50 **B,** January 8, 1932. Addition of phosphate equivalent to from 20 to 25 parts of P_2O_5 per million of softened water prevents boiler deposits. In case cited, from 2 to 6 kg. per 100 cubic metres (20 to 60 p.p.m.) have been used without corrosion, or priming. Phosphate should be added uniformly by suitable feed. At higher concentration (80 to 100 parts of P_2O_5 per million) phosphate may be used to loosen formed scale.—*W. G. Carey.*

Cause of Chemical Odor of Drinking Water. W. Uglow and M. Boltin. Zeitschrift für Hygiene, **112:** 655–659, 1931. Chemistry and Industry, **51:** 2, 50 **B,** January 8, 1932. Odor of chlorinated phenols is destroyed by addition of sodium, or ammonium, hydroxides, carbonates, or bicarbonates; but reappears on acidification. Dechlorination with sodium thiosulphate, or sulphite, does not render water odorless.—*W. G. Carey.*

Chemically Improving Drinking and Service Water. G. A. Krause. Chemistry and Industry, **51:** 18, 370 **B,** April 29, 1932. British Patent 366,429 of 31:8:31. Waters containing excessive amounts of sodium, or magnesium, sulphate may be improved by precipitation with barium chloride, carbonate, or aluminate. Excess of barium may be removed with calcium sulphate, either as gypsum, or as porous slab, or filter bed, in such quantity, or at such rate, that excess sulphate ions are unlikely to pass into solution again as calcium sulphate.—*W. G. Carey.*

Determination of Traces of Aluminium Hydroxide in Water Clarified by Aluminium Sulphate. L. Gizolme. Annales des Falsifications, **24:** 587–589, 1931. Chemistry and Industry, **51:** 18, 370 **B,** April 29, 1932. In modification of Auger's method for determinating aluminium hydroxide with sodium alizarinsulphonate, disturbing effect of calcium salts is avoided by adding sufficient 0.1 N formic acid to give distinct coloration when the same sample contains 0.1 p.p.m. aluminium hydroxide. Coloration deepens gradually (up to 1 hour being necessary when traces only are present). If 3 drops of glycerol (density 1.26) are added, colorimetric comparison may be made after two minutes.—*W. G. Carey.*

Continuous Control of the pH Value of Water. W. Kordatzki. Chemiker-Zeitung, **56:** 19–20, 1932. In apparatus described, water flows over end of tube from which solution of quinhydrone in acetone issues at regulated speed. Mixed solution is received in apparatus having usual electrodes separated by saturated potassium chloride. Respective flows of water and of quinhydrone

solution are regulated by movement of mercury in tubes of the liquids, mercury being controlled by rise and fall of water in connected vessel having siphon tube to draw off water at certain height.—*W. G. Carey.*

Membrane Filters for Water Filtration. W. Hoffmann. Z. f. angewandte Chemie, **45**: 143–146, 1932. Membrane filter will remove further quantity of impurity from sand filtered water. Detailed analyses are given of a brown moor water in crude state, after aëration, after filtration through sand and membrane filters, and after a combination of these treatments. Water after sand filtration was clear and colorless, but contained 3 p.p.m. iron and became brown on boiling. Aëration and filtration through 10- or 20-second membrane filter gave clear water, only faintly yellowish on boiling, containing only 0.1 p.p.m. iron, free from colloidal matter, and practically sterile.—*W. G. Carey.*

Preservation of Samples of Water and Aqueous Soil Extracts. S. M. Dratchev and R. A. Kalichnikova. Zeitschrift für analytische Chemie, **87**: 173–179, 1932. Of various preservatives examined, mercuric oxide and amalgamated copper had greatest bactericidal action on water and industrial effluents and exerted marked stabilising action on nitrates and sulphates; but no substance effecting permanent preservation was discovered.—*W. G. Carey.*

Apparatus for Testing Hardness of Water. United Water Softeners and H. S. Lawrence. Chemistry and Industry, **51**: 19, 373 **B**, May 6, 1932. British Patent, 367,606 of 27:3:31. Soap solution and water are admitted through parallel jets into transparent vessel in which liquid level is maintained constant by siphon. Amount of froth observed, in conjunction with proportion of soap used, indicates hardness.—*W. G. Carey.*

Indicating and Regulating Content of Chlorine, or Similar Water Purifying Agents, in Flowing Water, or Sewage. G. Ornstein. Chemistry and Industry, **51**: 20, 402 **B**, May 13, 1932. British Patent 367,821 of 19:9:30. Difference of potential produced between two electrodes, immersed respectively, in treated and untreated water, is used to indicate free chlorine content and to regulate rate of application. Electrodes need not be dissimilar, but that in treated water should lie on positive side of hydrogen in electromotive series. They may be placed in main conduit, above and below point of treatment, or in electrolytic cell through which streams of treated and untreated water are passed, and are connected together through a galvanometer, needle of which operates device regulating addition of purifying agent.—*W. G. Carey.*

Determination of Hardness of Water. J. Leick. Zeitschrift für analytische Chemie, **87**: 81–110, 1932. Chemistry and Industry, **51**: 22, 450 **B**, May 27, 1932. Comparative tests show that Blacher's potassium palmitate method gives most accurate results. Iron up to 100 parts per million and aluminium up to 30 parts do not interfere. Manganese behaves like calcium and magnesium and can be determined accurately by titration with palmitate. Colloidal silica and organic substances in proportions usually found in boiler feed

water do not interfere, while sodium and potassium salts interfere only at high concentrations. Calcium alone may be determined by precipitation as oxalate from faintly acetic acid solution followed by permanganate titration; correct results are obtained by use of empirical factor: 1 cubic centimeter of 0.05 N permanganate is equivalent to 1.466 mgm. CaO.—*W. G. Carey.*

Photometric Micro-Analysis of Water. I. C. URBACH. Mikrochem., 10: 483–504, 1932. Chemistry and Industry, 51: 22, 450 B, May 27, 1932. General account, followed by review of methods for determination of nitrate in water. Details are given of photometric determination of nitrate by brucine method. —*W. G. Carey.*

Water Treatment Today and—What of the Future ESKEL NORDELL. The American City. Part I. 46: 5, 97, May, 1932. Part II. 46: 6, 71–74, June, 1932. Popular article on water treatment, discussing at some length undesirability of hardness, its removal, and advantages to the community of softened water.—*Arthur P. Miller.*

Electrical Developments for Pumping Stations. R. C. ALLEN. The American City, 46: 5, 72, May, 1932. Year 1931 showed marked decrease in pumping projects for municipalities. Completed projects, although fewer in number, were generally of larger size than for previous year. Some large 1931 installations are cited.—*Arthur P. Miller.*

New Water Works for a South American City. GEORGE C. BUNKER. The American City, 46: 5, 75–80, May, 1932. Cali, capital of department El Valle, Colombia, South America, has now modern water purification plant. Open, unlined canal conveys water from Cali River to plant. Metered consumption figure of 66 gallons per capita daily was used for design. Initial 8-m.g.d. capacity can be doubled later without interfering with operation. Plant includes 3 adjoining mixing chambers, 2 parallel settling basins, 8 rapid sand filters, chlorinating apparatus, riffle type aërator in 8 units, reservoir, pumping station, and wash-water tank. Alum solution is introduced through perforated lead trough installed above weir across mixing chamber and strikes incoming raw water just after it flows over crest. Stilling baffles have been installed in settling basins because of strong winds which blow nearly every afternoon. Bacteriological examinations of plant effluent have been entirely satisfactory. Cost of operation and maintenance, exclusive of interest and depreciation, is \$9.84 per m.g.—*Arthur P. Miller.*

Unique Layout on Restricted Site Features Filter Plant at Ossining, N. Y. ALBERT N. AERYNS and NICHOLAS S. HILL, JR. The American City, 46: 4, 53–57, April, 1932. Water of poor physical quality and desirability of conserving seepage from storage reservoir were important factors in bringing about modernization of Ossining, N. Y., water supply. New plant includes filtration, aëration, and pumping equipment. Water is aërated through spray nozzles as it enters raw water settling basin and again when it enters filtered water basin. It is also chlorinated in both raw and filtered state. Plant was

constructed across valley of Indian Brook, just below Indian Brook reservoir, and in such way as to cut off seepage flowing from reservoir down that small valley. Pool thus formed above new plant is utilized as preliminary settling basin. Low-lift pumps transmit filter effluent to clear water basin situated on hillside adjacent, which also serves as wash-water tank. Plant is compactly and conveniently arranged: nearly all filtering and pumping operations can be conducted within filter house.—*Arthur P. Miller.*

The New Water Supply of O'Fallon, Illinois. JOHN A. FULKMAN. The American City, 46: 4, 75–76, April, 1932. New supply is procured from East St. Louis and Interurban Water Co.; discarded supply was drawn from abandoned coal mine. Eight miles of 10-inch pipe line, towards East St. Louis, had to be built, as well as 10,000 feet of additional distribution lines in the town. De Lavaud centrifugal cast iron pipe and Leadite joints were used. Leakage tests on line showed only 75 gallons per inch-mile diameter. Financing of this work under Illinois laws is described.—*Arthur P. Miller.*

The Chemical Solidification of Loose Soils. K. A. POHL. Engineering Progress, 8: 85–88. April, 1932. In 1924–26 patents were issued to Dr. H. JOOSTER in Germany for process, originally designed for potassium and salt mines, of converting quartzose sandy deposits into condition resembling sandstone by successive impregnations with silicic acid and salty solutions, whereby silica-gel is precipitated with petrification as result. Sandy soils containing 20 percent of quartz are particularly suitable and coarse gravel and rubble can be solidified with addition of sand. Impregnating is done under pressures up to 1400 pounds per square inch by means of strong 1-inch tubes. Silicic acid is applied in 20-inch stages to entire depth to be petrified. Salty solution is also applied in sections, but in upward direction, by raising the tubes. Petrification takes place within radius of 20 to 28 inches around each tube. First cost of equipment is low, and where process is repeatedly applied, cost of chemicals is from \$9 to \$18 per cubic yard of petrified soil. This process improves soil as to compressive strength, impermeability, and resistance to attack of chemical agents.—*R. H. Oppermann.*

Public Wash-Houses at Liverpool, England. Engineering, 133: 258–259, February 26, 1932. Wash-houses in Liverpool began when Mrs. C. WILKINSON allowed use of her back kitchen as such during cholera epidemic of 1832. Today Liverpool has 11 wash-houses capable of accommodating 610 people at a time. Service is made use of by 12,000 individuals a week. Slipper baths and wash-houses are operated together, latter being open in daytime and former in evening, all the year round, giving good load factor for heating plant and producing considerable gain in general health of poorer classes. Burroughs Gardens has 99 wash stalls and 100 drying horses; Kensington, built as part of unemployment relief scheme, has 35 wash stalls and 40 drying horses. Equipment consists of troughs for washing clothes, rinsing, and boiling. Centrifugal hydro-extractors dry clothes sufficiently in 1 to 2 minutes. Clothes horses are provided in chambers in which air at 170° is circulated at rate giving complete change 3 times per minute.—*R. H. Oppermann.*

Singapore Obtains Increased Water Supply. G. B. Gifford-Hull. Compressed Air Magazine, 37: 3680–3684. Population of 550,000 now has in excess of 30,000,000 gallons daily available from new development entailing 2 projects. First project consists of 2 concrete dams, 120 feet and 30 feet high, respectively, forming basin capable of holding 1,220,000,000 gallons. Dams are across Pulai II and Pulai III, two streams from watershed 40 miles away. Aëration and sedimentation tanks and mechanically operated filters are installed. Second project consists of 2 earth dams with concrete core walls, one 65 feet high, across the main Pontian stream, and the other, 45 feet high, across lower end of a valley. They furnish storage of 3,200,000,000 gallons. The two supplies are connected by steel pipe line 30 inches in diameter and 3½ miles long. Pumping plant can pump aganst head of 340 feet, each of 8 pumps being driven by 360-h.p. gas engine. Total cost of undertaking is estimated at $22,000,000 and supply is counted on to be adequate for next 20 years.—*R. H. Oppermann.*

The Development of San Antonio's Water Works. J. B. Nealy. Natural Gas, 8: 44, June, 1932. First water supply of San Antonio, Tex., was distributed by "aquadores," Mexican water carriers, carrying water in buckets from nearby San Pedro Creek. In 1877, reservoir was built and water from it was distributed by gravity. High-pressure artesian well was completed in 1891 and steam pumps were used for direct distribution through mains. At present there are three plants including 28 wells varying from 900 to 1300 feet, with capacity of 75,000,000 gallons daily and with customers numbering 47,000. Pumps are steam driven, using gas fired boilers, after coal and oil had both been tried. Each boiler is equipped with two large gas burners firing directly into firebox. They consist of three parts only: door and frame, gas manifold, and refractory mixing block; latter becoming incandescent and projecting heat at great speed among the boiler tubes.—*R. H. Oppermann.*

Modern Pipe Joints. A. Thau. Engineering Progress, 8: 43, 44, 45, February, 1932. Kiel Cap consists of sheet steel covering over joint so as to leave sealed hollow space in which, in event of leakage of joint, pressure equal to that in pipe will be established. Threaded plug is provided for examination, or inspection. Seiwert Filled Sleeve consists of a 2-part cast iron sleeve surrounding pipe. Split is sealed by strip of sheet lead, the two halves being held together with stout bolts. Inside is filled with compound mixture of oils, rubber, and other ingredient, becoming plastic upon cooling. —*R. H. Oppermann.*

Eijkman's Test Applied to Tropical Water Supplies. J. Taylor and A. N. Goyle. Indian Journal of Medical Research, 18: 1177–1202, 1931. From Chemistry and Industry, 51: 25, B 530, June 17, 1932. In tropics, absence of *B. coli* is not satisfactory criterion of safety. Eijkman's test is more trustworthy than are tests for lactose fermenters at 37°, even when latter test is supplemented by citrate, methyl-red, and Voges-Proskauer tests.—*W. G. Carey.*

Pretty Boy Dam, Engineering Feat, $2.5 Millions. Manufacturers Record, August, 1932, pp. 26–27. New unit adds 20 billion gallons to Baltimore's reserve supply from Gunpowder River. Secondary reservoir conserves overflow of Loch Raven Dam. Original contract price, $996,000: installed cost, 2.5 million dollars. Total excavation, all classes, 400,000 cubic yards. Describes construction features, handling of materials, and general engineering features.—*E. B. Besselievre.*

Protective Bathing Facilities by Use of an Ammo-Chlorine Boat. CHAUNCEY A. HYATT. Municipal Sanitation, 3: 9, 370, 71, September, 1932. In 1931, Forest Preserve District of Cook County, Illinois, was confronted with problem of controlling contamination in certain sewage-polluted streams used as bathing beaches. Portable type of chlorine boat, mounted on two-wheeled trailer, was designed and attached to ordinary automobile. In addition to chlorinator and ammoniator of dry feed type, boat was fitted with racks for carrying at least 1000 pounds liquid chlorine, or ammonia. Trailer, left attached, served to retard boat speed and protect propeller. Single block and tackle made launching and beaching easy. Chlorine masks were standard safety equipment and found desirable, though not absolutely essential. Medium size outboard motor helped diffuse the chlorine. Manner of treatment varied with location and wind conditions. Author concludes that it is possible, at least temporarily, to control bacterial content of certain natural, or semi-natural, swimming locations; that, if physical conditions make it feasible, better results could be obtained with continuous, than with intermittent treatment; that few, if any, natural swimming areas offer possibility of satisfactory control obtainable in well-designed pool. One table and four illustrations included.—*R. E. Noble.*

NEW BOOKS

Rates, Revenues and Results of Municipal Ownership of Water Works in the U. S. R. E. MCDONNELL. Published by Burns and McDonnell Engineering Company, Kansas City, Missouri. Paper 6 by 9 inches. Price $1.00. Municipal ownership of public water supplies has grown from one municipally owned plant of a total of sixteen in 1800 to approximately 7800 municipally owned plants of the approximately 10,800 plants in 1932. Of the 94 cities, of the U. S. with over 100,000 population (1930 Census), over 87 percent owned their water works systems, all of the 20 largest cities being in this group. Water is the cheapest commodity known, costing consumers of various classes from 2 to 4 cents per ton, as compared with other commodities, such as sand and gravel at about 75 cents per ton, or food stuffs costing hundreds of dollars per ton. The greatest strides in protection of public health have been made under municipal ownership of water supplies. A list of 49 North American cities having populations of 100,000 and over and operating filtration plants shows that 92 percent of the plants are publicly owned. Adequate water supply of satisfactory quality is a most important factor considered in the location and establishment of new industries. Advantages of softening of public water supply are pointed out. Cities operating filtration plants can,

by softening, save consumers much money at small additional expense. Many municipally owned plants now include softening. A list of 90 cities having water softening plants includes but three under private ownership. A table showing the cost of water softening only in 24 plants shows unit costs ranging from $2.21 to $57.65 per million gallons, the highest cost including pumping, depreciation, interest etc. Discussion of relative merits, from water consumer's standpoint, of private and public ownership of water supply systems favors latter. Governing motive of privately owned utility is to make a profit; governing motive of municipally owned utility is to render service to the consumers. Acquisition of water systems is a combined engineering and legal procedure and must be so well founded as to carry it through court action if necessary. Engineering appraisal and report on financial, structural, and functional aspects of the properties under consideration are essential. Two methods are available for financing purchase of existing water system, or construction of a new one: (1) bond issue to be retired by general taxation and (2) bond issue to be retired from revenues of the project. A tabulation records revenues, expenses, and net profits of 100 municipally owned plants and shows an average net profit of $1.28 per capita. Detailed data are presented showing results of municipal operation of water plants at Omaha, Nebraska; Milwaukee, Wisconsin; and New York City. Economy results from combined operation of municipal water and electric systems. List of 315 cities operating both water and electric utilities is given. Many towns are able to pay local governmental expenses from utility earnings so that no local taxes are levied. List of 83 such towns in the U. S. is appended. Following table summarizes average net costs per month to consumer for various quantities of water as delivered, calculated to common basis from published rate schedules of 250 water plants.

CITIES			AVERAGE NET COST PER MONTH (DOLLARS PER THOUSANDS OF GALLONS)					
Plant ownership	Number	Population (thousands)	5	10	50	100	500	1,000
Municipal	100	Less than 25	1.56	2.80	10.97	18.85	68.07	122.58
	50	25–50	1.48	2.70	13.35	19.45	74.29	136.27
	25	50–100	1.28	2.18	8.90	16.39	59.98	105.55
	50	Over 100	1.13	1.96	8.63	15.91	64.98	119.71
	Total 225	Average	1.41	2.52	10.75	18.06	67.87	123.09
Private	25		2.24	4.00	15.74	27.77	97.68	148.53
Percent higher for privately owned			58.87	58.73	46.42	53.77	43.92	20.67

—*R. L. McNamee.*

Chemical Character of Surface Waters of Virginia. W. D. Collins, E. W. Lohr, K. T. Williams, H. S. Haller, and O. C. Kenworthy. Bulletin No.

3, Division of Water Resources and Power, Virginia Commission on Conservation and Development, University, Virginia, 1932. Prepared in coöperation with U. S. Geological Survey. Paper; 6 by 9 in., pp. 148. The topography, geology, and climate of Virginia are discussed in their relation to quality and rate of flow of surface waters. The nature and concentration of suspended matter, color, dissolved mineral matter, hardness, silica, iron, sodium and potassium, chlorides, and nitrates of surface waters of the State are discussed in general terms. Detailed statements of physical characteristics of the watersheds and of chemical character of the waters cover the basins of the Potomac, Rappahannock, York, James, Chowan, Roanoke, New, Big Sandy, and Tennessee Rivers. Virginia surface waters now supply public water systems serving over 750,000 people and many industries. Some means of water treatment are employed with almost all surface waters and especial attention is given to industrial supplies to produce a water suitable for the intended use. The records of analyses of single and composite samples for the river systems of the State occupy over half of the work, and together with the statements of physical characteristics of watersheds comprise the most valuable section of the bulletin to the engineer who is interested in these natural resources in prospect of their development for supply purposes. An insert map of the State presents a graphical picture of the average chemical composition of the rivers. This work is an admirable example of efficient joint action between state and national agencies in surveys of this nature. Virginia is the first state which has coöperated in so liberal a manner as to produce a comprehensive report presenting the combined results of both state and national agencies. Federal, state, municipal and private interests have in this work an appraisal of Virginia's resources in surface waters which should be most valuable and which will obviate much duplication of effort in surveys for particular projects.—*R. L. McNamee.*

Sixty-Fourth Annual Report of the Commissioners of Water Works in the City of Erie, Pa., for the Year Ending December 31, 1930. Annual report, consisting chiefly of extensive tabulations regarding financing, operation, and extensions, together with the usual brief description of works and schedule of water rates. Contracts were let during the year to extent of $997,888 in connection with construction of new West pumping station and filtration plant at Tracy Point and good progress was made on that project. Estimated population of city is 123,000 and estimated population served 120,000. Daily average consumption was 24,881,896 gallons, equivalent to 207.35 per capita, or 89.93 after deducting water delivered through meters to industrial and large commercial users. Cost of collecting, purifying and pumping water, including depreciation, was $27.361 per million gallons. Net addition of $121,874.83 was made to surplus during year and water was furnished for municipal purposes without cost to value of $55,260.02. In addition to latter, $29,698.44, interest on water works funds, was paid to city by banks. Average cost of coal used was $2.746 per ton, and number of gallons of water pumped per pound of coal consumed was 311.12. Water supplied has been practically sterile at all times and free of taste and odor. Since March 11th, ammonia has been successfully employed for prevention of taste following chlorination.

Equipment was installed in December to enable use of chlorine instead of calcium hypochlorite for sterilization. Average amounts of alum, hypochlorite, and ammonia used during year were 0.359 grain per gallon, and 5.2 and 0.48 pounds per million gallons respectively. Wash water averaged 2.58 percent. Of 301 samples of raw water examined, 66 contained *B. coli* in 1 cc. and 4 in 0.1 cc., while all of the 601 samples of filtered water examined gave a negative test for this organism in 10 cc.—*R. E. Thompson.*

Sixty-Fifth Annual Report of the Commissioners of Water Works in the City of Erie, Pennsylvania, for Year Ending December 31, 1931. 89 pp. As usual, this report is replete with detailed tabulations of operating statistics. Construction of new West station and filter plant has nearly been completed: several illustrations of new plant are included. Population supplied during year is estimated at 120,000, daily consumption averaging 22,043,291 gallons, per capita figures being, inclusive and exclusive, respectively, of water supplied through meters, 183.69 and 106.74 gallons. There were 31,749 services in use at end of year, 1,177 (4.542 percent) being metered. Pitometer water waste survey was made during year. Distribution system comprises 241 miles of mains, 2 to 36 inches in diameter, and 32,000 service connections, $\frac{3}{4}$-inch to 16 inches in diameter. Only 4 leaks in mains were discovered, involving loss of 285,000 gallons per day. Of service connections, 83 were found defective, leaks being about equally distributed between street and property of consumers, waste from this source totaling 637,000 gallons per day. In connection with survey, detailed inspections of fixtures within buildings were carried out, revealing 2069 defective installations involving waste of 1,525,000 gallons per day. Report of survey embodied recommendation favoring universal metering. Net addition to surplus during 1931 was $64,041.47, exclusive of water supplied for public use, without remuneration, to value of $61,733.63. Water sales were $25,322.62 lower than in 1930. Cost of collecting, purifying, and pumping water (including depreciation) was $29.125 per million gallons. Gallons pumped per pound of coal consumed averaged 320.70. Average amounts of alum, chlorine, and ammonia (taste prevention) used, were 0.225 grain per gallon and 1.82 and 0.63 pounds per million gallons, respectively. Wash water averaged 2.62 per cent of water filtered. Table is included showing monthly average turbidity, alkalinity, color, and bacterial count in raw and filtered water, monthly average temperature, and results of *B. coli* tests. Of 604 ten-cc. samples of filtered water examined, none contained colon bacillus. Usual brief description of works and schedule of water rates is appended.—*R. E. Thompson.*

Sanitation and Water Purification. A. PARKER. Reports of the progress of applied chemistry (issued by Society of Chemical Industry, London), **16**: 585–620. Survey of world progress during 1931 in water purification, sewage disposal, trade waste water treatment, river pollution prevention, atmospheric pollution prevention and public cleansing. In all 164 references are given to American, Canadian, and European current literature. Under water purification author deals with advances in disinfection and states that chlorination is generally employed and that taste difficulties have been overcome in

majority of cases by either (1) superchlorination followed by treatment with sulphur dioxide, sulphites, thiosulphates, or activated carbon, (2) ammonia and chlorine, (3) permanganate before, with, or after chlorination, or (4) filtration through granular activated carbon, or addition of powdered carbon; examples are given of American, English, and German plants. Iodine in water, "catadyn" sterilization, plumbo-solvency, base exchange softening, feed water treatment with aluminates, phosphates, etc., and purification by electro-osmosis are all dealt with. Under sewage, author discusses percolating filters, activated sludge dilution methods, sewage chlorination, and nature of sewage colloids, while under trade wastes, advances in treatment of effluents from beet sugar factories, creameries, tanneries, gas and coke works, breweries, wool scouring, and cellulose manufacture are discussed. Under river pollution, recent reports of Advisory Committee are dealt with, and under atmospheric pollution, methods of removing smoke, ash, dust, and sulphur from flue gases are described.—*W. G. Carey.*

Metropolitan Water Board (London) 26th Chemical and Bacteriological Report for Year Ending December 31, 1931. Sir A. Houston. 40 pp. and illustrations. Average daily consumption, 281.3 million gallons. Taste troubles were avoided, but filtration difficulties were considerable, owing to algal and other growths. Bacteriological tables show very high bacterial purity, 90 percent of *B. coli* tests being negative in 100 cc. for all Thames-derived waters. High ammoniacal nitrogen is due to ammonium sulphate added before chlorination to prevent taste troubles, but albuminoid nitrogen, oxygen absorbed, and color are higher than customary, due to weather conditions. In nearly every instance only filtered water is chlorinated [from 0.2 to 0.3 p.p.m.] and results when ammonia precedes chlorine show from 94.8 to 100 percent freedom from *B. coli* in 100 cc. Waters which feed filters have been systematically examined chemically and bacteriologically, results showing great improvement due to storage, while primary filtration effects striking reduction in ammoniacal nitrogen. Resistance to filtration and microscopical appearance of these pre-filtration waters are also considered. Streptococcus test is described, using same primary MacConkey tubes as for *B. coli*, heating subculture thereof for 10 minutes at 60°C., after which plate cultures are made with Drigalski and Conradi's medium. In experiments carried out with ozone treatment, raw Thames water after rapid filtration showed 95.2 percent reduction in bacteria, while reduction of organisms surviving 80°C. for 10 minutes was also affected. Laboratory tests show that earthy and iodoform tastes are removed by ozone. Experiments using catadyn sand with water inoculated with sewage showed perfect sterilization therewith. Important section deals with paratyphoid outbreak which, although due to milk, involved water supply, owing to sewage discharge into brook feeding river supply. As precautionary measure, brook was chlorinated (2.5 p.p.m.) for about a year, by which treatment 10,000 *B. coli* per cubic centimeter and 11 *B. paratyphosus* per 500 cc. were reduced to no *B. coli* in 100, and no *B. paratyphosus* in 500 cc. River supply was discontinued for 10 days, after which filtered river water was chlorinated.—*W. G. Carey.*

OBTAINING UNEMPLOYMENT RELIEF

Judging from the correspondence received at Headquarters, apparently many unemployed engineers throughout the United States are unaware that various forms of relief are available in their own communities. Practically every state, county, and city has raised or appropriated funds to provide for the relief of the unemployed. These funds are being expended in various ways.

Experience during the past months indicates that all engineers out of work and in need of assistance should first acquaint themselves with the local method of providing relief. This may be done by getting in touch with any of the following persons in their community: (1) officers of local sections of national engineering societies, (2) officers of local engineering clubs, (3) the City Engineer, or (4) the County Engineer.

If the member is so located as to be unable to reach any of the persons mentioned, a letter to the Secretary of the Society will bring suggestions as to what seems to be the next best procedure.